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WATER RIGHTS ANALYSIS PACKAGE (TAMU WRAP) MODEL DESCRIPTION AND USERS MANUAL

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INTRODUCTION

Report Scope and Organization

TAMUWRAP is a Water Rights Analysis Package (WRAP) developed at Texas A&M University (TAMU). The generalized computer model simulates the management and use of the streamflow and reservoir storage resources of a river basin, or multiple basins, under a prior appropriation water rights permit system. The TAMUWRAP model presently includes three computer programs, called WRAP2, WRAP3, and TABLES. A stream/reservoir/rights system simulation may be performed with either of two alternative versions of the Water Rights Analysis Program (WRAP2 or WRAP3). The computer program TABLES performs various manipulations of WRAP2 or WRAP3 input and output data, including developing tables which organize and present the simulation results.

This report describes the TAMUWRAP package (WRAP2, WRAP3, and TABLES) and provides instructions for its use. The main report and six appendices are organized as follows. The main report is a general discussion of TAMUWRAP capabilities, computational procedures, input data requirements, and simulation output. Appendices A and B provide instructions to be followed by the user in developing input data files. A simple example is presented in Appendix C to illustrate the format of input and output data. The variables and subroutines incorporated in WRAP2, WRAP3, and TABLES are defined in Appendices D, E, and F, respectively. The main report and Appendices A, B and C are essential for applying the model. The information provided by Appendices D, E, and F is useful for anyone interested in examining the Fortran code, but is not needed to use the executable (compiled) programs.

Water Rights

Generally, in the United States, legal rights to the use of streamflow are based on two alternative doctrines, riparian and prior appropriation. The basic concept of the riparian doctrine is that water rights are incidental to the ownership of land adjacent to a stream. The prior appropriation doctrine is based on the concept, "first in time is first in right." In a prior appropriation system, water rights are not inherent in land ownership, and priorities are established by the dates that users first appropriate water. Water law in 29 eastern states is based strictly on the riparian doctrine. Nine western states have a pure prior appropriation system. Ten western states, including Texas, originally recognized riparian rights but later converted to a system of appropriation while preserving existing riparian rights. Two other states also have hybrid systems incorporating the two doctrines in a somewhat different manner (Getches 1990 and Rice and White 1987).

TAMUWRAP is a flexible generalized computer model for simulating surface water management, which can be adapted to a broad range of applications, which do not necessarily have to involve water rights or any particular type of water rights system. However, the model is designed specifically to facilitate incorporation of a water rights priority system, such as the prior appropriation permit systems common in the western states, in river basin and reservoir system modeling.

Development of TAMUWRAP was originally motivated by the recent implementation of a permit system in Texas. Surface water law in Texas evolved historically over several centuries. Early water rights were granted based on various versions of the riparian doctrine. A prior appropriation system was later adopted and then modified. The Water Rights Adjudication Act of 1967 merged the riparian water rights into the prior appropriation system. The allocation of surface water has now been consolidated into a unified permit system. The water rights adjudication process required to effect transition to the permit system was initiated in 1967 and was essentially completed in 1987. Modeling and analysis of water rights is becoming an increasingly important aspect of water resources development and management in Texas, as well as in other states.

Model Development Background

A research project, entitled "Optimizing Reservoir Operations in Texas," was performed from September 1986 through August 1988 as a part of the cooperative research program of the Texas Water Resources Institute and U.S. Geological Survey. The Brazos River Authority also participated in sponsoring the project. The study is documented by Wurbs, Bergman, Carriere, and Walls (1988) and Wurbs and Carriere (1988). The research focused on developing improved modeling capabilities for analyzing hydrologic and institutional water availability and for formulating and evaluating management strategies for increasing reservoir yields. A system of 12 reservoirs in the Brazos River Basin, operated by the U.S. Army Corps of Engineers and Brazos River Authority, provided a case study. Several existing generalized computer simulation models were applied in the study.

The need for a generalized water rights analysis model became evident during this study. The original version of TAMUWRAP was developed and applied in the Brazos River Basin study. The original TAMUWRAP significantly expanded modeling capabilities. However, it was recognized that additional future work was needed to improve TAMUWRAP capabilities, particularly in regard to two areas: (1) organization and presentation of the voluminous simulation output data and (2) modeling a comprehensive range of multiple-reservoir, multiple-purpose system operating strategies. The recently revised and expanded TAMUWRAP documented by the present report reflects improvements in these two areas.

The original version of TAMUWRAP was developed during the period September 1987 through May 1988 in conjunction with the larger two-year research project described above. The model and its application in the Brazos River Basin study are documented by a master of science degree thesis (Walls 1988), journal paper (Wurbs and Walls 1989), and technical report (Wurbs, Bergman, Carriere, and Walls 1988).

WRAP2, WRAP3, and TABLES were developed during the period June 1990 through March 1993, as part of a Texas Advanced Technology Program research project entitled "Natural Salt Pollution and Reservoir System Yield." Model development and application to the Brazos River Basin are documented by Dunn (1993). Development of the revised TAMUWRAP, particularly WRAP3 and TABLES, involved essentially coding completely new computer programs.

The original TAMUWRAP, now termed WRAP1, has been replaced by WRAP2 and TABLES. The combined WRAP2 and TABLES represent an improved version of the original model, which provides essentially the same basic modeling capabilities. The computational algorithms have been refined, some additional capabilities have been added, the input data format has been changed, and the output format has been totally restructured. Since all the capabilities of the original TAMUWRAP (WRAP1) are provided by WRAP2 and TABLES, WRAP1 is not expected to be used in the future and is not included in the present report. This report documents the present TAMUWRAP package, which consists of WRAP2, WRAP3, and TABLES.

The relationship between WRAP2, WRAP3, and TABLES is discussed in detail later in this report. WRAP3 contains all the modeling capabilities of WRAP2 as well as significant additional optional capabilities. WRAP3 is more complex than WRAP2 and provides greatly expanded capabilities for simulating multiple-reservoir, multiple-purpose reservoir system operations. Any input data file which can be run with WRAP2 can also be run with WRAP3 with only minor modifications. However, a WRAP3 input file may specify optional capabilities which cannot be provided by WRAP2. TABLES can be used with either WRAP2 or WRAP3. Since WRAP3 includes all the capabilities of WRAP2, in a sense, WRAP2 is not really needed. However, WRAP2 is still considered pertinent because the computer code is much simpler. The expanded capabilities provided by WRAP3 necessitate a significantly more complicated computer program. Working with the simpler WRAP2 could possibly be advantageous in some situations.

In both the earlier and more recent studies cited above, TAMUWRAP was applied to the Brazos River Basin. The 45,600 square mile Brazos River Basin extends from eastern New Mexico southeasterly across the state of Texas to the Gulf of Mexico. Although the studies focused on a particular system of 12 major reservoirs, the entire basin was treated as an integrated system to reflect the interactions and impacts of the many water users. About 1,040 public agencies, cities, private companies, and individual citizens hold over 1,300 permits to use the waters of the Brazos River and tributaries. The water rights include diversions totalling 2,178,000 acre-feet/year and storage capacities totalling 4,567,000 acre-feet in 598 reservoirs. Municipal, industrial, irrigation, mining, and recreation uses account for 51%, 29%, 19%, 1%, and 0.1% of the permitted diversions. The two hydroelectric power plants on the Brazos River have no priority water rights. The studies utilized naturalized monthly streamflows at 20 gage locations covering the 1,020-month period from January 1900 to December 1984.

The earlier study (Wurbs, Bergman, Carriere, and Walls 1988) focused on performing a yield/reliability analysis of the 12-reservoir system, which properly reflected the impacts of the numerous other water rights in the basin. TAMUWRAP was used to compute streamflows hydrologically and legally available to the water rights associated with the 12-reservoir system. The TAMUWRAP-computed available streamflows were inputted to the computer programs HEC-3 and HEC-5, which were used to perform various yield/reliability analyses. TAMUWRAP simulations were also used to perform various sensitivity analyses. Dunn (1993) focused on applying the expanded capabilities provided by WRAP3 for comprehensive modeling of multiple-reservoir system water rights and operating strategies.

Two other recently developed versions of the model are not included in the present report. A network flow version of WRAP2 reads the same input files as the WRAP2 described herein and provides the same output (Yerramreddy 1993).

However, the simulation computations are performed using a network flow programming algorithm. TABLES is used with the network flow version of WRAP2 identically as with the conventional WRAP2 documented here. Another model development effort currently underway involves addition of salinity considerations in WRAP3 and TABLES. In the water quality version of WRAP3, diversions are constrained by specified allowable salt concentrations as well as by the quantity of water available.

Disclaimer

All interested persons are welcome to use the TAMUWRAP model. However, the model must be used at the user's own risk. Conceptual mistakes, fortran coding errors, data inaccuracies, and misinterpretation of results are always possible with any computer model. The authors of this report, their employers, and the research sponsors assume no responsibility for model accuracy, results, or usage.

MODEL OVERVIEW

Modeling Capabilities

TAMUWRAP is designed for use by water management agencies, consulting firms, and university researchers in performing reservoir/river system water availability and reliability studies. The model can be used in various types of planning studies to evaluate alternative water management strategies for specified water use scenarios. Model results can be used to evaluate the capability of the river basin to satisfy existing water rights and the amount of unappropriated streamflow remaining for potential additional water rights applicants. Reservoir system simulation studies can be performed to evaluate alternative operating policies or the impacts of adding new reservoirs to a system.

TAMUWRAP basically provides an accounting system for tracking inputted streamflow sequences, subject to specified reservoir storage capacities and diversion and instream flow requirements. Water balance computations are performed for each time interval of the overall simulation period. The model provides flexibility for adaptation to a broad range of modeling approaches. Typically, a simulation will be based on the assumptions of (1) a repetition of historical period-of-record hydrology and (2) the full amounts of all permitted diversions are withdrawn as long as water is available from streamflow and/or specified reservoir storage capacity. However, synthetic streamflows, rather than naturalized gaged streamflows, could be used, and various other water use scenarios could be simulated. Although water supply and use systems are viewed in terms of prior appropriation water rights, the model can be readily applied to river basins with riparian rights or no water rights at all. The model is designed for a monthly computational time interval but could be modified for other time intervals such as a day or week.

The generalized computer model provides the capability to simulate a stream/reservoir/use system involving essentially any stream tributary configuration. Interbasin transfers of water can be included in the simulation. Closed loops such as conveying water by pipeline from a downstream location to an upstream location on the same stream or from one tributary to another tributary can be modeled. The system configuration is represented in the model by a set of control points. Input data includes: naturalized monthly streamflows at each control point covering the simulation period; control point location, diversion amount, storage capacity, priority date, type use, and return flow specifications for each water right; storage versus area relationship for each reservoir; monthly reservoir evaporation rates; and monthly water use distribution factors for each type of water use. The WRAP3 version of the model allows specification of a comprehensive range of reservoir system operating rules and also inclusion of hydroelectric power generation. Flood control aspects of multiple-purpose reservoir system operations can also be included in an approximate manner.

For each month of the simulation, TAMUWRAP performs the water accounting computations for each water right, in turn, on a priority basis. The computations proceed by month and, within each month, by water right with the most senior water right in the basin being considered first. TAMUWRAP computes diversions and diversion shortages associated with each water right. Permitted reservoir capacity is filled to the extent allowed by available streamflow. Reservoir evaporation is computed and incorporated in the water balance. Return flows are computed as a fraction of diversions and re-enter the stream at user-specified control points. An accounting is maintained of storage levels in each reservoir and streamflow still available at each control point.

TAMUWRAP output includes diversions, diversion shortages, hydroelectric energy generated, hydroelectric energy shortages, reservoir storage levels, reservoir evaporation, return flows, streamflow depletions, and unappropriated streamflows for each month of the simulation for each water right or control point. Reliabilities associated with specified water rights can also be tabulated. Simulation results can be organized, tabulated, and summarized in various optional formats.

Comparison of Individual Computer Programs

TAMUWRAP presently consists of three computer programs: WRAP2, WRAP3, and TABLES. As previously discussed, the original TAMUWRAP (now called WRAP1) is a single computer program which has been superseded by the combined WRAP2 and TABLES. WRAP2 and TABLES provide the following improvements over the earlier WRAP1: (1) refinements in the computational algorithms, (2) minor modifications in the input data format, and (3) a major restructuring and expansion of the output format.

The computer program TABLES is used with either WRAP2 or WRAP3. TABLES reads WRAP2 or WRAP3 input and/or output data files and writes various user-selected data listings and tables. The simulation input and output data is extremely voluminous. TABLES provides flexible options for organizing and presenting the simulation results.

A stream/reservoir/rights system simulation can be performed with either WRAP2 or WRAP3. However, WRAP3 provides expanded capabilities, not incorporated in WRAP2, related primarily to providing flexibility in modeling a comprehensive range of reservoir system operating strategies and associated system water rights. WRAP2 is limited to simple single-reservoir or run-of-river water rights. Any input data file developed for WRAP2 can also be run, with minor modification, with WRAP3. However, a WRAP3 input data file may specify optional capabilities which are not available from WRAP2. The only advantage of WRAP2 over WRAP3 is the relative simplicity of the computer code. The additional capabilities incorporated in WRAP3 result in a significantly different and much more complex computer program. WRAP3 provides the following modeling capabilities which are not included in WRAP2.

1. Whereas WRAP2 allows only one reservoir to be associated with any particular water right, WRAP3 allows multiple-reservoir water rights. A water right diversion can be met by releases from a number of reservoirs based on user-specified release rules. Both WRAP2 and WRAP3 allow multiple water rights to be associated with the same reservoir.

2. Unlike WRAP2, WRAP3 allows a water right diversion to vary as a function of reservoir storage and/or streamflow.

3. WRAP3 includes hydroelectric power operations; WRAP2 does not.

4. WRAP3 allows an inactive pool (dead storage) to be specified, as well as a two-zone active conservation pool. WRAP2 limits each reservoir to a single active conservation pool, with inactive storage being reflected only in the inputted storage/area relationship used in the evaporation computations.

5. WRAP3 has optional capabilities for handling negative incremental streamflows, which are not provided by WRAP2.

Program Structure and Computer Requirements

The TAMUWRAP programs (WRAP2, WRAP3, and TABLES) are coded in standard Fortran 77. Fortran source codes and executable (compiled) versions of the programs are available on diskette. The subroutines and variables used in the three programs are defined in Appendices D, E, and F. The programs have been compiled and executed on both IBM compatible microcomputers and VAX mini-computers. The programs will run on an IBM compatible microcomputer that has at least 512 kilobytes of random-access memory (RAM) and Microsoft MS-DOS (version 2.1 or greater) or equivalent operating system. The amount of hard disk storage required depends on the size of the input and output data files. The simple example presented in Appendix C can be run without a hard disk. The Brazos River Basin studies cited above required about eight megabytes of available hard disk storage.

The programs are batch-oriented. Input data files can be developed using any editor. A WRAP2 or WRAP3 output file is read by TABLES as an input file. The three programs are compiled and executed as separate programs.

Dimension Limits and Other Features

The programs are presently dimensioned for 50 control points, 2,000 water rights, 15 water use types, and 12 periods per year. The number of years in the period-of-analysis is not limited. The dimension statements in the Fortran codes can be easily changed. The model uses a monthly computational time interval but could be modified for another time interval such as a week or day. Any consistent set of units can be used. Inputted multiplier factors associated with the streamflow and evaporation rate input data can be used for unit conversions.

Glossary

A glossary of selected terms is provided as Table 1. Each of the terms included in Table 1 is defined and discussed in more detail in various parts of this report. The definitions are specifically from the perspective of the use of the terms in this report.

Table 1
GLOSSARY

TAMUWRAP Computer Programs

TAMUWRAP - This generalized simulation model is presently composed of three computer programs: WRAP2, WRAP3, and TABLES.

WRAP - The term WRAP refers to both WRAP2 and/or WRAP3. The Water Rights Analysis Program simulates a river basin stream/reservoir/use system.

WRAP1 - This original version of TAMUWRAP is now superseded by WRAP2 and TABLES.

WRAP2 - This version of WRAP does not contain system operating rules and other features provided by WRAP3.

WRAP3 - This expanded version of WRAP provides system modeling capabilities and other options not available in WRAP2.

TABLES - This computer program develops tables and data listings from WRAP2 or WRAP3 input and output files which organize and summarize the simulation results.

Streamflow Data

naturalized streamflows - Historical gaged streamflow data adjusted to remove the impacts of reservoir construction, water use, and other activities of man in the river basin are provided as WRAP input data.

incremental streamflows - The naturalized streamflow data represent total or cumulative flows at a control point. The computational algorithms, as well as input and output data, are based on total flows rather than incremental flows. However, WRAP3 includes an option for checking for negative incremental flows. An incremental flow is the difference between total flows at adjacent control points.

streamflow depletions - WRAP computed streamflow depletions are the streamflow amounts appropriated to meet water rights diversions and/or refill reservoir storage capacity. Streamflow depletions are associated with a particular water right.

unappropriated streamflows - WRAP computed unappropriated flows, associated with a particular control point, are the portions of the naturalized streamflows still remaining after the streamflow depletions are made for all the water rights included in the simulation.

Water Rights

water right - A water right consists of a permitted annual water diversion amount (or permitted annual hydroelectric energy amount), a permitted storage amount which can be maintained in a reservoir, control point location, and priority number, along with associated data such as monthly use factors, return flow specifications, and various data (including

Table 1 Continued
GLOSSARY

operating rules) for multiple reservoirs which can make releases to satisfy the permitted diversion, hydropower, and reservoir storage targets.

permitted diversion - the target amount of water to be appropriated from streamflow at a control point location and reservoir storage at the same or other locations. Monthly permitted diversion amounts are inputted as an annual diversion amount and set of 12 monthly distribution factors.

actual diversion - permitted diversion target limited by water availability.

shortage - permitted diversion minus actual diversion.

return flow - An amount of water computed as the actual diversion multiplied by an inputted return flow factor is returned to the stream system at a user-specified control point in either the same month as the diversion or the next month.

run-of-river water right - a water right with zero reservoir storage capacity.

instream flow requirement - WRAP contains no variable specifically to denote an instream flow target. Instream flow requirements are specified using a water right permitted diversion with a return flow factor of 1.0.

priority - a numerical value included in the input data for a water right indicating the relative seniority of the right. The inputted priority numbers will typically represent prior appropriation dates but could represent any other type of priority indicator. In each period of the simulation, water rights are considered in turn and available water appropriated in order of the priorities.

senior or junior rights - A water right is senior or junior relative to another water right depending on the priority number included in the input data for each right. A senior right has the highest priority, which is represented by the smallest priority number (earliest date or other priority indicator), and is considered first in the computations.

control point - a modeling mechanism for representing the location of streamflows, reservoirs, diversions, return flows, and other system features.

period reliability - the percentage of the total months (periods) in the overall simulation period-of-analysis during which a specified permitted diversion target (or hydroelectric energy target) is met without shortage.

volume reliability - the total volume of actual diversions (or total firm hydroelectric energy generated) during the simulation period-of-analysis expressed as a percentage of the corresponding total permitted diversion or hydroelectric energy targets.

Table 1 Continued
GLOSSARY

WRAP3 System Operating Rules

type 1 water right - allows a permitted diversion target (or hydroelectric energy target) and/or storage target in one reservoir to be met from streamflow depletions and releases from multiple reservoirs.

type 2 water right - is the same as a type 1 right except a reservoir storage target (refilling of storage capacity in the one reservoir) is not allowed.

type 3 water right - is the same as a type 2 right except the permitted diversion target can be met only from reservoir releases.

type 4 water right - the permitted diversion target is specified as a function of system reservoir storage and naturalized streamflow.

inactive pool - the bottom pool of a reservoir from which releases or withdrawals cannot be made except by evaporation.

active pool - reservoir storage pool from which releases and withdrawals are made. An active pool can be divided into two vertical zones for purposes of defining multiple reservoir release rules.

primary and secondary reservoirs - Up to 50 reservoirs can be associated with each water right. However, storage capacity can be refilled in only one primary reservoir by each right. The other secondary reservoirs make releases to meet the water right diversion but cannot be refilled by the water right. A secondary reservoir for one water right can be a primary reservoir for another water right.

permitted firm energy - inputted hydroelectric energy targets.

secondary energy - additional hydroelectric energy, above the permitted firm energy, which could be generated incidentally by releases for more senior water rights diversions, assuming unlimited turbine capacity.

flood control operation - Although WRAP was designed for conservation operations with no features included specifically for flood control, flood control reservoir operations can be modeled by combining types 4 & 1 water rights.

Miscellaneous

computational time period - Although TAMUWRAP is presently limited to a monthly time interval, the model was designed to be easily modified for other time intervals such as a week or day.

input data record - An input record is a line of data, not to exceed 80 characters, in an input data file. Each WRAP input record begins with a two-character record identifier. Each TABLES input record begins with a four-character record identifier.

SYSTEM COMPONENTS

A river basin stream/reservoir/rights system is represented in the model by the following interrelated components: (1) control points, (2) basin hydrology, (3) water rights, (4) reservoirs, (5) return flows, (6) hydroelectric power, and (7) reservoir system operating rules. Actually, reservoirs, return flows, hydroelectric power, and reservoir system operating rules are all subcomponents or features of the water rights component. The characteristics of the model components and subcomponents are represented by the input data.

Control Points

Control points provide a mechanism to model the locational configuration of the river basin system. Control points are specified in the input data to indicate the location of streamflow data, reservoirs, water rights diversions, and other system features. The computations are based on knowing which of the other control points are located downstream of each control point. Essentially any configuration of stream tributaries, reservoirs, and within-basin or interbasin conveyance facilities can be modeled. Streamflow data must be provided for all control points included in a simulation. Each water right can be assigned a separate control point. Alternatively, water rights can be aggregated such that the water rights assigned to a given control point include all water rights located between that control point and the next adjacent control point. Multiple water rights at the same control point all have access, in priority order, to the streamflow available at the control point. Any number of reservoirs can be associated with a single control point, but each control point is limited to one set of inputted streamflow and reservoir evaporation rate data.

Basin Hydrology

The basin hydrology consists of streamflows and reservoir evaporation rates at each control point for each month (time period) of the simulation period-of-analysis. Monthly streamflows and evaporation rates are provided by the user as input data. The model allows streamflows and evaporation rates at a control point to be computed by multiplying data inputted for that location or another location by a user-specified factor. This feature can be used for unit conversion factors and/or for transferring streamflow or evaporation data from one control point location to another. Although any units can be used, typical units are acre-feet/month for streamflows and feet/month for evaporation rates. Normally, the user will input streamflows which have been naturalized to remove the nonhomogeneities caused by the activities of man in the river basin. Net reservoir evaporation rates are normally used, which have been adjusted for precipitation to reflect the change in the precipitation-runoff relationship caused by construction of a reservoir project.

Water Rights

In the model, a water right is represented by the following input data: (1) a control point location, (2) annual diversion amount, (3) reservoir storage capacity, (4) priority number, (5) type of use, (6) return flow factor, (7) return flow control point location, and (8) optional water right group. As discussed later, WRAP3 also allows specification of (1) multiple-reservoir system operating rules, (2) water rights diversions as a function of reservoir storage and/or naturalized streamflow, and (3) hydroelectric power operating rules. The diversion amount, storage capacity, priority number, and return flow factor may be zero. The model uses the type of use to assign the proper monthly water use distribution factors. A set of 12 monthly factors are provided as input data for each type of use (such as municipal, industrial, irrigation, etc.) to distribute the annual water right diversions over the year. The priority number typically represents dates. For example, a priority date of May 12, 1965 is inputted 19650512, which is a larger number than the priority corresponding to any earlier date. The return flow factor is the fraction of the diversion which is returned to the stream at a user-specified control point.

An actual water right permit may be represented by any number of "model" water rights or sets of values for each of the variables cited above. Also, in certain applications, several water rights may be combined and inputted to the model as a single aggregate water right. The model provides considerable flexibility in describing water rights. However, the total number of rights in the model may be somewhat misleading since a single appropriator holding a single water right permit may have several rights listed representing different components or features of the water right permit. For example, a water right which includes three different uses, such as municipal, industrial, and irrigation, would be treated as three separate water rights, since the monthly water use distribution factors are different for the various uses. A single reservoir may have several water rights with different combinations of priority dates, storage capacities, and other variables. The diversion amount and storage capacity can be assigned different priorities by treating the right as two separate rights, one with zero storage capacity and the other with a zero diversion. As discussed later, a single "system water right" may be represented by a combination of several WRAP3 type 1, type 2, type 3, and/or type 4 water right input data records.

Instream flow requirements are not defined as a separate variable in the computational algorithms of the model. An instream flow requirement is specified in the input data as a water right diversion with an associated return flow factor of 1.0.

Reservoirs

As discussed above, reservoir storage capacity is provided with the water rights input data. Several water rights can be associated with a single reservoir. The storage capacity associated with each water right is the total cumulative capacity to which the reservoir can be refilled under that right or permit, assuming the reservoir has been drawn down in previous months and streamflow is now available for refilling. WRAP3 allows releases from multiple reservoirs to meet the one diversion target and maintain storage in the one reservoir specified by a single water right. WRAP3 includes options for specification of multiple-reservoir release rules and also diversions which are a function of reservoir storage and/or naturalized streamflows.

The storage capacity associated with a water right is defined differently in WRAP2 and WRAP3 in regard to inactive storage. WRAP3 allows the storage level to fall below the top of inactive pool due to evaporation; WRAP2 does not. Otherwise, both versions properly reflect inactive storage even though the approach is somewhat different. In WRAP2, the water right storage capacity is for active storage only, and the storage versus water surface area input data reflects the effect of the active storage being in addition to inactive storage. In WRAP3, the water right storage capacity includes inactive as well as active storage capacity, and an inactive pool is explicitly designated. The storage capacity is defined exactly the same in WRAP2 and WRAP3 for reservoirs with no inactive pool.

A storage capacity versus water surface area relationship is provided as input data for each reservoir. The storage versus area relationship is used by the model in the evaporation computations. The reservoir evaporation volume for a given month is the computed average water surface area during the month times the appropriate inputted net evaporation rate. Two optional formats are provided for inputting a reservoir storage versus area relationship. A table of storages versus areas can be inputted. The model applies linear interpolation to the table to determine the area corresponding to a previously computed storage. Alternatively, values of the coefficients a, b, and c can be provided as input data for the following equation which is incorporated in the model:

$$A = aS^b + c$$

where S denotes storage and A denotes water surface area.

Any number of water rights can have storage capacity in the same reservoir. For reservoirs with multiple rights, the storage capacity associated with each water right is the cumulative or total capacity. The reservoir can be filled to this level by the water right. Streamflow depletions, diversions, and the other quantities computed for a particular water right represent values assuming no other more junior water rights exist but senior rights do exist. For purposes of performing computations for a given water right (except for hydropower rights) in a given month, the beginning-of-month and end-of-month storage is not allowed to exceed the storage capacity associated with that water right. However, with the exception of WRAP3 type 4 rights, diversions associated with a water right are met from the total cumulative storage capacity of the right. Thus, a junior water right could empty a reservoir, even though the depleted storage capacity affects water available to a senior right at the same reservoir during the next month. Hydropower rights allow the beginning-of-period and end-of-period storage to exceed the storage capacity of the hydropower right due to other rights at the same reservoir. WRAP3 type 4 rights allow diversions to be specified as a function of reservoir storage.

Return Flows

Return flows can represent water discharged back into the stream after use, such as municipal and industrial wastewater treatment plant effluent or irrigation return flows. Return flows can also represent conveyance facilities such as canals, pipelines, and pumping plants.

Return flows are computed in the model as a user-specified fraction of diversion amounts. A diversion return flow can reenter at any user-specified control point, which could be located downstream or upstream of the diversion location or on a different tributary. The return flow can also represent an interbasin transfer of water. The control points of origin and destination of the diversion return flow can be located in different river basins. The diversion amount, return flow factor, and return flow control point location are part of the water right input data.

Timing of return flows is also a user-specified option. The return flows may be returned during the same month as the associated water right diversion or during the next month. Since water rights are considered in priority order, the return flows associated with a junior water right will not affect the water available to a senior right unless the return flow is carried over to the next month.

Hydroelectric Power (WRAP3)

Hydroelectric power water rights can be included in a simulation performed with WRAP3, but not WRAP2. A hydroelectric power water right is represented by the following input data: (1) location indicated by control point, (2) annual firm energy target, (3) reservoir storage capacity, (4) priority number, (5) plant efficiency factor, (6) constant tailwater elevation, (7) reservoir storage versus water surface elevation table, and (8) set of 12 monthly distribution factors. The annual firm energy requirement is apportioned to each month of the year in the model using the inputted monthly distribution factors. Hydroelectric power can also be included in the multiple-reservoir system operating rules discussed below.

For each month of the simulation, the firm energy target is met as long as sufficient water is available from streamflow and reservoir storage. An energy shortage occurs if sufficient water is not available to meet the user-specified firm energy requirement. The model also computes a form of secondary (surplus) energy. Secondary energy represents additional energy, above firm energy, that potentially could be generated by passing reservoir releases for downstream diversions through the turbines. Only reservoir releases for water rights senior to the hydropower right are considered in computing secondary energy. The capacity of the power plant is not considered, and thus the secondary energy is based on assuming unlimited capacity. Secondary energy is treated by the model as a "negative" firm energy shortage. No releases from storage or streamflow depletions are made if previous releases for senior rights are sufficient to meet or exceed the firm energy requirement.

Reservoir Operating Rules (WRAP2)

The reservoir operating procedure in WRAP2 is very simple. For a given month, the water right diversion target is met from reservoir inflows and storage as long as sufficient water is still available considering other more senior water rights. A shortage occurs if sufficient water is not available. The reservoir storage capacity associated with the water right is refilled whenever water is available. Each water right is limited to a specified storage capacity in a single reservoir. Of course, a water right can be run-of-river with zero storage capacity.

Multiple rights at the same reservoir allow refilling the reservoir to different levels depending on the priorities of each of the rights. However, the reservoir is treated as a single active conservation pool. There are no zones and no designated inactive (dead storage) pool. The user-inputted storage versus surface area data should be adjusted to reflect inactive storage so that the evaporation is computed correctly.

Reservoir System Operating Rules (WRAP3)

A major difference between WRAP2 and WRAP3 is the comprehensive range of reservoir system operating rules which can be modeled with WRAP3. WRAP3 provides considerable flexibility in modeling complex system operations and associated water rights permits.

Reservoir system operating rules are modeled in association with water rights. Water rights are addressed here from the perspective of input data records and associated computations performed by the model. An actual system operating policy and associated water right permit can be modeled by a combination of any number of water rights input records. The various types of water rights discussed here can be combined in a variety of ways to represent a particular actual "system water right."

Water Right Types

Each water right input record includes specification of the type of water right as either type 1, 2, 3, or 4. The types of system operations which can be included with each type of water right are summarized in Table 2 and described below.

Table 2
Types of WRAP3 Water Rights

Allowable Operations	Type of Water Right 1	2	3	4
diversions from streamflow depletions	yes	yes	no	yes
refill one reservoir from streamflow depletions	yes	no	no	no
releases from multiple reservoirs	yes	yes	yes	yes
hydroelectric power generation	yes	no	no	no
diversion requirements specified as a function of reservoir storage and naturalized streamflows	no	no	no	yes

In a typical river basin, most actual water rights will likely be represented as type 1 rights. A type 1 right allows a diversion to be met from streamflow depletions and/or storage in one or more reservoirs. One reservoir can be refilled from streamflow depletions or releases from other reservoirs in the system. The one reservoir which can be refilled and the diversion must be located at the same control point. The other reservoirs in the system, from which releases or withdrawals are made, can be located at any of the control points in the basin. A type 1 right can include either a diversion requirement or a hydroelectric energy generation requirement, but not both. Of course, two type 1 rights can be used in combination to model both hydropower and a diversion. Both the diversion and energy requirements can be zero, in which case the right would simply refill storage in the one reservoir. Releases or withdrawals can be made from a maximum of 50 reservoirs. A run-of-river diversion right can be represented as a type 1 (or type 2) right with no reservoirs. A run-of-river hydropower right can be represented as a type 1 right with one reservoir with inactive but no active storage capacity. Although the water right types are not pertinent to WRAP2, the WRAP2 procedure is equivalent to a type 1 right with one or no reservoir and no hydropower.

A type 2 right provides a mechanism for modeling a situation in which releases or withdrawals from one or more reservoirs supplement streamflows in meeting a diversion target without replenishing storage in any of the reservoirs. A type 2 right is identical to a type 1 right except that no reservoir is refilled. A type 2 right could be mimicked by a type 1 right with an extra reservoir with zero storage capacity.

A type 3 right is identical to a type 2 right except the diversion target can be met only by releases or withdrawals from reservoir storage. For example, a diversion could be met by releases from one or more upstream reservoirs without allowing diversion of unregulated streamflow entering the river below the dams. Unlike a type 3 right, a type 1 or 2 right makes reservoir releases only after the streamflow at the diversion location is depleted.

A type 4 right allows a permitted diversion to be specified as a function of reservoir system storage and naturalized streamflow at the diversion location. Thus, buffer zone operations can be simulated in which certain water demands are curtailed whenever reservoir storage falls below specified levels. Input data includes a table of diversion amount versus total storage in specified system reservoirs, as well as the annual water right diversion target with associated monthly water use distribution factors incorporated in the other water right types. For a given month, the permitted diversion target is computed as the minimum of: (1) the value determined by linear interpolation of the diversion versus storage table and (2) the value determined from the permitted annual diversion and monthly use factors. An optional feature is also included in the model which limits releases from reservoirs to a user-specified percentage of the naturalized streamflow at the diversion location.

Multiple Reservoir Release Rules

All water rights are limited to one permitted diversion or energy generation target amount. A type 1 water right can also include maintenance of storage in one "primary" reservoir. (Of course, any number of reservoirs can each have one or more separate rights to maintain their individual storages.) Releases or withdrawals can be made from one or more "secondary" reservoirs to meet the diversion or hydropower target and refill storage in the one primary reservoir associated with a right. WRAP3 is dimensioned to allow a water right to include a maximum of 50 reservoirs.

In a multiple reservoir system, a set of rules is required for the model to determine amounts to be released from each of the alternative reservoirs. For example, Figure 1 illustrates a system composed of four reservoirs and one diversion, which is subject to the constraint of another more senior water right. The system diversion can be met from streamflow depletions at control point CP-4 and releases from reservoirs RES-A, RES-B, RES-C, and RES-D located at control points CP-1, CP-2, CP-3, and CP-5. Since reservoir RES-D at control point CP-5 is not located upstream of the system diversion location at control point CP-4, its role is limited to minimizing the adverse impacts on water availability of the senior right at control point CP-6. In each month of the simulation, the computations include determination of the amount of water to release from each

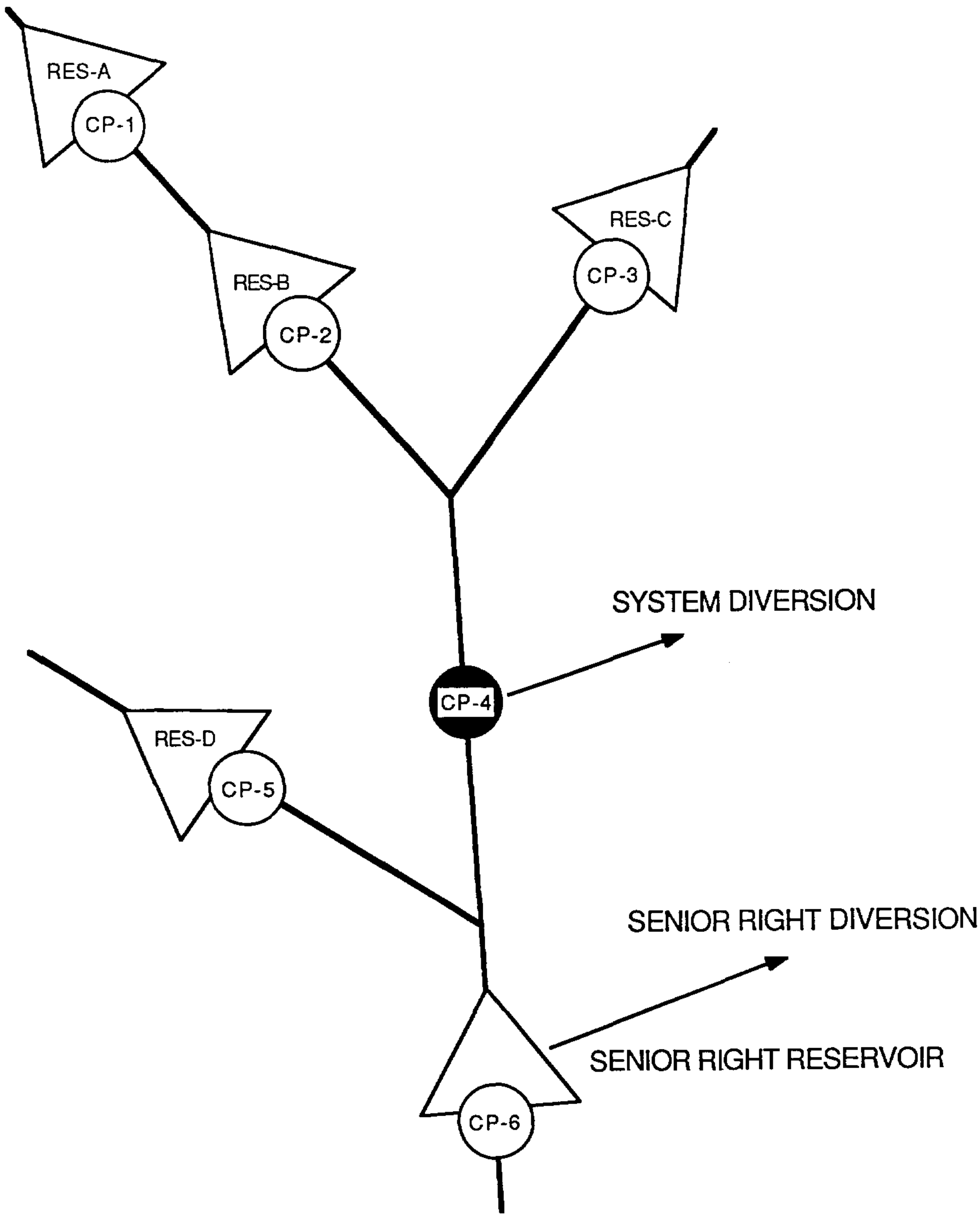

FIGURE 1. MULTIPLE RESERVOIR SYSTEM

subcomponent of the four-reservoir system to meet the diversion at CP-4, based on balancing storage depletions in the reservoirs.

An important aspect of the multiple reservoir system release rules involves the impact on water availability of the other more senior rights in the river basin. For example, the senior right at control point CP-6 is not part of the four-reservoir/one-diversion system but impacts the water available to the system. The model maintains an accounting of the amount by which the senior right at CP-6 reduces water availability at the other control points and allows releases to be made from reservoir RES-D, as well as RES-A, RES-B, and RES-C, to mitigate this amount. Therefore, to this limited extent, reservoir RES-D contributes to meeting the permitted system diversion at CP-4 and maintaining storage in the system reservoirs, even though RES-D is not located upstream of CP-4. Likewise, reservoir RES-A can contribute to refilling storage in RES-B and RES-C, and vice versa, in a similar manner.

In this example, water is conveyed only by gravity flow in the stream channels. However, WRAP3 includes optional capabilities for simulating pump/pipeline systems. For example, water could be conveyed by pipeline from reservoir RES-D to control CP-4 to contribute to the system diversion. If appropriately flagged in the input data, reservoir RES-D will be treated just like reservoirs RES-A, RES-B, and RES-C in making multiple-reservoir releases to meet the system diversion at CP-4, even though RES-D is not located upstream of CP-4.

As illustrated by Figure 2, a reservoir includes an active pool and inactive pool. The inactive pool is dead storage from which releases or withdrawals cannot be made. The inactive pool can be drawn down only by evaporation. Releases and withdrawals to meet water rights requirements are made from the active pool. For purposes of developing multiple-reservoir operating rules, the active pool is divided into two zones. Zone 1 can be eliminated by specifying its cumulative capacity as equal to that for zone 2. Zone 2 may be eliminated by specifying its cumulative capacity as equal to the inactive storage capacity. Multiple reservoir release decisions are based on balancing the storage, as a percent of zone capacity, in each reservoir. Zone 1 must be empty in all the reservoirs in the system, in order for releases to be made from zone 2 of any of the reservoirs. Reservoir storage balancing is based on computing a ranking factor for each reservoir in the system as follows.

$$\textit{rank factor} = (\textit{weighting factor}) \left[\frac{\textit{storage content in zone}}{\textit{storage capacity of zone}}\right]$$

The release is made from the reservoir with the greatest value for the rank factor. If the release results in the reservoir storage dropping from zone 1 into zone 2 while storages in the other reservoirs are still in zone 1, the release is limited to that required to empty zone 1 in that reservoir. Additional releases are made, as required, from zone 1 of one or more other reservoirs. The "weighing factor" for each reservoir used in the above formula is specified by the user in the input data. If the values of the weighing factor are the same for all the reservoirs, the operating rule simply balances the percent depletion of either zone 1 or zone 2 of each reservoir. The reservoirs are not precisely balanced since, in each month, only one selected reservoir releases for the water right, unless the release depletes the storage capacity of the zone. The weighing factors allow some reservoirs to be emptied faster

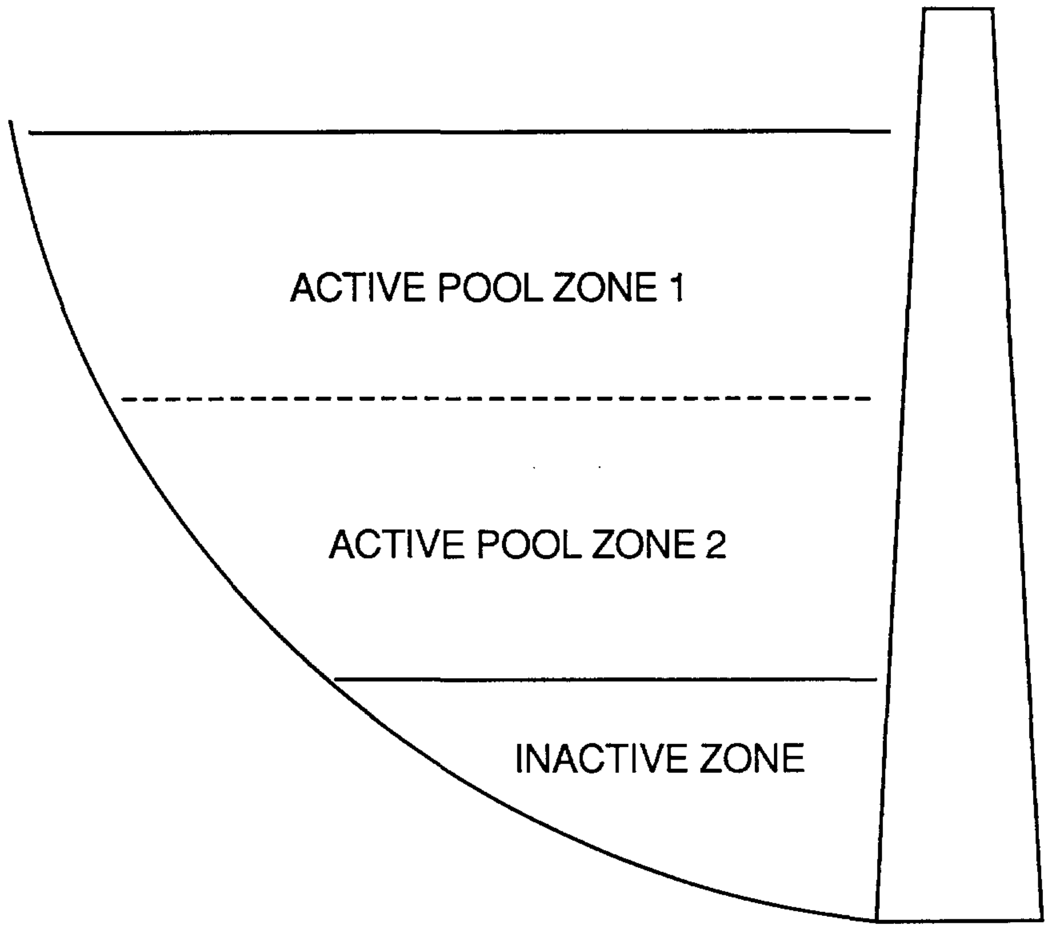

FIGURE 2. WRAP3 RESERVOIR POOLS AND ZONES

than others. Thus, the user defines the operating rules by inputted values for zone 1 and zone 2 cumulative storage capacities and the weighing factor for each reservoir in the system.

A type 4 water right provides additional flexibility for specifying operating rules for either a multiple reservoir system or a single reservoir. With a type 4 right, the permitted diversion amount is inputted as a function of the total storage in the one or more reservoirs included in the system. The reservoir releases can also be limited to not-to-exceed a percentage of the naturalized streamflow at the diversion control point. Thus, diversions can be partially or completely curtailed as available reservoir storage is depleted or reservoir releases limited to a specified percentage of the streamflow which would have existed without basin development.

Flood Control Operations

The various types of water rights can be combined in any number of ways to represent actual water rights permits and system operating strategies. The model was designed to provide flexibility for analyzing a comprehensive range of operations for water supply, hydropower, instream flow maintenance, and other conservation purposes. Although no special features are included specifically for flood control, reservoir flood control operations can be included in an approximate manner in modeling multiple purpose operations.

Flood control operations are based on emptying designated flood control pools as rapidly as possible without contributing to streamflows at downstream control points exceeding target allowable nondamaging levels. A type 4 water right can be used to specify an instream flow requirement (diversion with 100% return flow) as a function of system storage. For flood control operations, the instream flow requirement would be specified as an allowable nondamaging channel capacity, if storage is in the flood control pool, and zero otherwise. A type 1 right, with a permitted diversion of zero, would be used to fill the flood control storage capacity of each reservoir. For a multiple reservoir system, the flood control pool of each reservoir would be designated as zone 1 to define release rules based on balancing storage depletions. Zone designation would not be necessary for a single flood control reservoir.

COMPUTATIONS PERFORMED BY WRAP2 AND WRAP3

Basic Concepts

The WRAP (WRAP2 or WRAP3) computations proceed by month (period) and, within each month, by water right on a priority basis with the right having the smallest priority number being considered first. The water right diversion amount is diverted as long as streamflow, not yet appropriated by senior water rights, or reservoir storage is still available. A shortage occurs if sufficient streamflow and/or storage are not available to supply the water right that month. The reservoir storage capacity associated with the water right is filled to the extent allowed by available streamflow.

The naturalized streamflow provided in the WRAP input data for each control point represents the streamflow which would occur at that location assuming no water users, reservoirs, or other activities of man in the river basin. WRAP computes streamflow depletions associated with each water right and unappropriated streamflows associated with each control point. An accounting is maintained of the effect of each streamflow depletion on streamflow availability at all other control point locations.

A streamflow depletion represents the streamflow taken by a water right in a given month to (1) meet the target water right diversion and (2) fill the reservoir storage capacity. Water rights diversions are supplied by streamflow depletions, as long as streamflow is available, and then by reservoir storage depletions, if reservoir storage is available. WRAP3 also provides the option for diversions to be met by releases from reservoir storage but not streamflow. Evaporation also depletes reservoir storage. A streamflow depletion in a given month will often include refilling of reservoir storage capacity depleted during previous months.

Unappropriated streamflow represents water still available after all streamflow depletions or the water that flows past the basin outlet into the ocean or other receiving body. The unappropriated streamflow is the portion of the inputted naturalized streamflow not used by the water rights included in the simulation. The computed unappropriated streamflows, as well as inputted naturalized streamflows, are treated as cumulative or total flows rather than incremental or local flows.

End-of-period reservoir storage content is computed in the model based on the water balance equation:

$$S_2 = S_1 + D - R - E$$

where S_2 and S_1 denote the storage at the end of the current and previous months, respectively, and D, R, and E denote streamflow depletions, releases or withdrawals, and evaporation during the month. The streamflow depletion (D) represents reservoir inflows minus spills and minus releases to meet downstream senior water rights. In the model, streamflow depletions are computed as the portion of streamflow used to refill reservoir storage and meet diversion requirements. Spills are not actually computed. The releases or withdrawals (R) are to meet diversion requirements of water rights associated with the reservoir.

Evaporation (E) is computed by multiplying the computed average water surface area during the month by an inputted net evaporation rate. The water surface area is determined from an inputted storage versus area relationship. Since the average area is dependent on both S_2 and S_1, an iterative solution of the water balance equation is required.

For a given month, the computations are performed for each water right in priority order. As the water rights are considered in turn, an accounting is maintained of the amount of streamflow still available at each control point location. Available streamflow at each control point is treated as total flows rather than incremental or local flows. As a first step in the computations for a water right, the amount of streamflow available to the right is determined as the minimum of the available streamflows at each of the downstream control points, including the control point of the water right. After the streamflow depletion, return flow, and other variable values are determined for a water right, the amounts of water still available at that control point and all downstream control points are decreased to reflect the streamflow depletion. The water available at the control point location at which the diversion return flow is returned as well as all downstream control points is increased to reflect the return flow. The next water right, in priority order, is then considered.

A fundamental concept of the model is that, with the exceptions noted below, each water right is impacted only by more senior water rights. During each period (month), as each right is considered in turn in priority order, the various quantities (such as diversions, diversion shortages, streamflow depletions, storages, etc.) are computed as if the other more junior rights did not exist. Thus, the most senior right in the river basin meets its permitted diversion target and refills its reservoir storage capacity as if no other water users or storage facilities existed in the basin. As explained below, exceptions to this basic concept are related to (1) return flows and (2) multiple water rights with storage capacity in the same reservoir.

Diversion return flows reenter at a user-specified control point during either the same month as the diversion or during the next month. With the user-specified option of the return flow returning during the same month as the diversion, senior water rights are not affected by return flows from junior water right diversions. However, with the next month option, junior right return flows, associated with diversions from either streamflow and/or storage, can increase the water available to senior rights.

Any number of water rights can include storage capacity in the same reservoir. In the computations for a senior water right, the beginning-of-period storage can be impacted by the computations for the previous period for junior rights at the same reservoir. Multiple rights in the same reservoir are modeled as follows. A reservoir storage capacity is included with the input data for the right. The storage capacity associated with a water right is the total or cumulative capacity to which the reservoir can be filled by the computations for that right. Unless a WRAP3 type 4 right is specified, storage depletions to meet diversions can be made by any of the rights associated with the reservoir until the active pool is completely empty. The end-of-period storage depends upon all the rights associated with the reservoir. For a hydropower right, the actual beginning-of-period and end-of-period storages are used in the computations, even if the capacity associated with the right is exceeded due to other rights. For a diversion right, the beginning-of-period and end-of-period storages used in the computations for that particular right are limited to not-to-exceed the storage capacity associated with the right. Because of this, the storage capacity for a junior right at a reservoir must be equal to or greater than the storage capacity of any senior right at the reservoir.

Organization of the Simulation

The computations and input/output data handling performed by WRAP2 and WRAP3 are outlined in Table 3 from a general overview perspective. After first reading a major portion of the input data, the simulation is performed in a set of three nested loops. The computations proceed by year and, within each year, by month. Within each month, the water rights are considered in priority order, and the computations are performed for each water right in turn. Certain output data records are written to the WRAP output file at the completion of each of the two inner loops. The output records are described in Table 5, which is discussed in more detail in the later section on WRAP input and output.

At the beginning of a WRAP execution, a subroutine reads all the input data except streamflows and evaporation rates. Various manipulations of the input data are performed including a ranking mechanism for identifying the priority order of the water rights.

The annual loop begins with reading the streamflow and evaporation data for each of the 12 months of that year. The computations are then performed on a monthly basis. The data on the control point and reservoir/hydropower output records, as listed in Table 5, represent summations for all rights associated with the control point or reservoir. Thus, these records are outputted each month at the completion of the water rights loop.

Most of the system simulation computations are performed within the water rights loop. For a given month, the computations are repeated for each water right in priority order. For a given water right, the computations begin with a determination of the streamflow available to the right. Streamflow availability is determined as the lesser of the streamflow amounts still available at the control point of the water right and at each of the downstream control points. Water balance computations are then performed to compute the streamflow depletion, reservoir evaporation, end-of-period storage, return flow, and diversion shortage for the water right. The interrelationships between the variables necessitate an iterative algorithm. For WRAP3 multiple reservoir system operations, the releases and storages for all the system reservoirs are computed. Upon completion of the water right computations, the streamflow amounts still available at the control point of the water right and at all downstream control points are decreased by the streamflow depletion. The streamflow amounts still available at the control point of the return flow and all downstream control points are increased by the return flow amount.

WRAP3 System Computations

The basic concepts and organization of the simulation described above are identical for both WRAP2 and WRAP3. However, WRAP3 contains optional capabilities, not included in WRAP2, related primarily to simulation of a comprehensive range of operating strategies for multiple-purpose, multiple-reservoir systems. WRAP3 also has optional capabilities for handling negative

Table 3
Outline of WRAP Simulation

*** Input Data

- read all input records except streamflows and evaporation rates
- rank water rights in priority order
- perform various other input data manipulations
- write first five records of output file

*** Annual Loop

- read streamflow and evaporation data for year

    *** Monthly (Period) Loop

        *** Water Right Loop
        - check streamflow availability
        - perform water balance computations
        - adjust available streamflows
        - write water rights output records

        ***

        - write control point output records
        - write reservoir/hydropower output records

    ****

****

incrementals in the streamflow input data. Another WRAP3 option provides flexibility in specifying reservoir storage levels at the beginning of the simulation. These features require additional input data and computations beyond the requirements for the basic WRAP2 simulation. The optional WRAP3 features, not included in WRAP2, are addressed below.

Water Right Types

As previously discussed, WRAP3 includes options for specifying a right to be one of four distinct types, 1, 2, 3, or 4, which are defined in Tables 1 and 2. The computations within the water rights loop proceed differently according to water right type. The differences are primarily in determining the permitted diversion amount for a right and in specifying how the permitted diversion is to be met. In all cases, the available streamflow is calculated as described in the previous section. The target streamflow depletion is then computed according to the type of right.

For type 1 rights, the target streamflow depletion is the permitted diversion amount plus the volume needed to refill storage in the primary reservoir, if one exists, accounting for evaporation and previous depletions made available to the primary reservoir by senior rights associated with that reservoir. A right is only allowed to refill storage in its primary reservoir, and only up to the storage capacity of the right. A streamflow depletion is then made to meet the target depletion. If the available streamflow is greater than the target depletion, the target depletion is removed from the available streamflow and the computations continue on to the next right in priority order. If there is not enough available streamflow to meet the target depletion, the additional amount (variable MAKEUP) is released from system reservoirs, according to the multiple reservoir release rules described previously.

The basic water right is a type 1. Computations for a type 1 right in WRAP3 are essentially identical to WRAP2. However, in WRAP2, a water right may be associated with only one reservoir. The additional amount needed to meet the target depletion cannot be released from other reservoirs. A WRAP3 simulation with all type 1 rights and no secondary reservoirs for any right is identical to a WRAP2 simulation. In both models, the permitted diversion amount is given priority over refilling of reservoir storage when insufficient water is available to meet the permitted diversion amount and refill storage. The computations to replenish storage in the primary reservoir also assume that the total capacity of the reservoir is that of the current right being examined. Subsequent junior rights may have storage capacities that are higher than the right in question, but this extra storage capacity is ignored by the current right.

Computations for a type 2 right are identical to a type 1 right except that a type 2 right is not allowed a primary reservoir in which to replenish storage. The target depletion for a type 2 right is simply the permitted diversion amount. Although a type 2 right is not allowed a primary reservoir, it is allowed to have secondary reservoirs from which to receive releases.

The target depletion for a type 3 right is computed identically to a type 2 right, but a type 3 right is not allowed to make a streamflow depletion. Because a type 3 right is not allowed to appropriate streamflow, the available streamflow is by definition zero. The permitted diversion is treated as an additional amount to be released from system reservoirs according to the multiple reservoir release rules. For water right types 1, 2, and 3, diversion shortages are calculated as the difference between the permitted diversion amount and the amount of diversion actually met.

Diversion requirements for type 4 rights are calculated as a function of several variables. After the available streamflow is determined, the permitted diversion is determined as the minimum of a fixed (storage-independent) target and the value determined from linear interpolation of the storage-diversion table input for the right. The fixed target is the inputted permitted annual diversion multiplied by a set of monthly distribution factors, as for the other water right types. If no limit on reservoir releases is desired, the required amount is met from streamflow depletion and reservoir releases, and the diversion shortage is calculated similar to a type 2 right. Reservoir releases, however, may be limited by an optional user input percentage of the naturalized monthly streamflow at the water right's control point.

Multiple Reservoir Releases

Beginning Versus End-of-Period Storage. For water rights allowed to receive releases from multiple secondary reservoirs, two options are available on which to base release decisions. As stated earlier, the secondary reservoirs eligible to release from a storage zone for a water right are ranked from high to low according to a priority number consisting of the product of a user input zone factor and the percent full of that respective reservoir zone. WRAP3 allows the user to specify whether to use the beginning-of-period storage or the intermediate end-of-period storage in computing the priority number. Using the beginning-of-period storage option will allow the user to track easily how the reservoir release decisions are made in a month. Using the end-of-period storage option more closely resembles real-time reservoir release decisions, but doesn't allow the user to track how the reservoir release decisions were made during a particular month because the storage levels used for a release are changed by the releases themselves and by junior water rights associated with the reservoir.

Release Constraints. Reservoirs upstream of a diversion location are assumed to make direct releases to meet a water right diversion requirement. Reservoirs located in basins other than that of the water right diversion are treated as if a conveyance structure exists to transport water directly to the diversion location. However, reservoirs that are physically able to release only to control points that are downstream of the diversion location are limited to streamflow depletions made by senior rights downstream of the diversion location. These reservoirs are referred to as "downstream" reservoirs. The amount of water that a downstream reservoir may release is limited to the amount of water that has been passed through the diversion location to meet senior water right depletions. The effect of this constraint is best described by example.

Referring to Figure 1, the three upstream reservoirs RES-A, RES-B, and RES-C are able to release directly to the system diversion location. Downstream reservoir RES-D is not. Assume naturalized inflows to control points CP-4 and CP-6 are 20 ac-ft and 30 ac-ft, respectively. The senior right diversion requirement at CP-6 is 17 ac-ft, while the system diversion requirement at CP-4 is 25 ac-ft.

The senior right reduces the available streamflow to the system diversion to 13 ac-ft, resulting in 14 ac-ft to be released from system reservoirs. Of the

20 ac-ft of inflow to CP-4, seven ac-ft were passed through the control point to meet the senior right diversion. This amount is the maximum that RES-D may release for the system diversion. Effectively, it is releasing the seven ac-ft to the senior right, freeing that amount of water for use by the system diversion. Of course, any of the upstream reservoirs RES-A, RES-B, and RES-C may release all of the 14 ac-ft if sufficient storage exists.

The downstream release constraint is determined on a control point basis. If a second system diversion exists at control point CP-4 that is junior to the first, the amount that RES-D may release for the second system diversion is constrained by the amount that RES-D released for the first. If RES-D released four ac-ft for the first system diversion, then it is limited to releasing three ac-ft for the second because a total of seven ac-ft were passed through the control point to the senior water right. WRAP3 maintains an accounting of depletions at and releases to each control point as well as an accounting at each control point of releases made from downstream reservoirs to determine the downstream releases constraints. If negative incremental inflows occur within a basin, specifying negative incremental options 1 or 2 may cause erroneous release decisions to be made due to the mechanism used in the accounting of flows.

WRAP3 includes an option that will remove the downstream reservoir releases constraint and treat a downstream reservoir as if a conveyance facility exists between the reservoir and the diversion locations.

Hydroelectric Power Computations

Hydroelectric energy computations are based on the following equations:

$$energy = (power)(time)$$

$$power = \gamma Q H e \ (unit\ conversion\ factor)$$

where: γ = unit weight of water
Q = discharge through turbines during month
H = head = mean reservoir water surface elevation for month minus tailwater elevation
e = plant efficiency
t = time interval

In the model, these equations are expressed as:

energy = QHe(POWFCT)

where: POWFCT = γt (unit conversion factor).

As discussed in a later section on units, the user can either input a value for POWFCT or use the default provided in the model.

If a water right is a hydropower right, a permitted firm energy is input instead of a permitted diversion amount. A reservoir storage versus elevation table and constant tailwater elevation are input in order to compute head. When a non-hydropower water right's diversion is met from a primary reservoir and/or secondary reservoirs, the water is released either through the reservoir hydropower turbines or directly from the reservoir pool, not passing through the turbines, depending upon the user's input specifications. The hydropower permitted diversion is computed as the additional release amount needed to meet the permitted firm energy target, considering all releases for more senior rights which pass incidentally through the turbines.

Because the energy produced is a function of both the flow through the turbines and the average head on the turbines, a different assumption is made as to the refilling of storage in the reservoir. In order to compute the energy produced correctly, the convention of ignoring storage capacity above the water right's capacity in a multiple-right reservoir is relaxed somewhat. A right will make streamflow depletions and receive releases from secondary reservoirs to meet the permitted firm energy as well as refill storage up to its permitted storage capacity. If the storage in the reservoir is above the capacity of the right, the right will make depletions and releases necessary to just maintain the storage level while meeting the permitted firm energy. The target depletion is computed as the additional water that must be passed through the reservoir turbines assuming that the end-of-period storage is either the water right's storage capacity or the current storage level, whichever is higher, plus the amount needed to refill storage. The storage used in the assumptions is the current end-of-period storage for that reservoir. Junior rights associated with that reservoir may increase or decrease that storage amount, changing the energy actually produced at the reservoir. The value output for the energy produced on a reservoir/hydropower record in a WRAP3 '.OUT' file represents the energy produced by the most junior hydropower right of the reservoir. The intermediate values of energy for senior rights is listed in the WRAP3 '.SYS' file.

The appropriate streamflow depletions and reservoir releases are then made. If the target depletion is less than the sum of the available streamflow and/or the secondary reservoir releases, the firm energy requirement is met without drawdown of the reservoir. If the target depletion is greater than that sum, the actual energy produced must be computed in an iterative manner because storage will be released from the reservoir to meet the firm energy requirement.

A run-of-the-river hydropower right, with no reservoir storage, may be modeled with zero storage in a "dummy" reservoir. The appropriate storage elevation curve entered would then be a constant elevation. A run-of-the-river hydropower right with inactive reservoir storage is modeled with the total storage capacity equal to the inactive capacity.

Optional Beginning-Period-Storage

The default assumption concerning reservoir storage at the beginning of the first period of the simulation is that all reservoirs begin the simulation full. It is possible, however, to specify a lower beginning-period-storage at any reservoir in the basin. This may be necessary to add conservatism to an analysis of water right reliabilities, to more closely model an actual circumstance, or because computer storage limitations necessitate dividing the simulation into two or more runs.

The output from the model is voluminous. It may be desired to simulate a portion of a long period-of-record on one run, and the rest of the period-of-record on ensuing runs. The beginning-period-storages at the reservoirs will simply be the ending storages from the preceding run. If the next month option is specified for return flow from any water right, it would also be necessary to add the return flow from the last period of the preceding run to the inflows of the first period of the current run.

Negative Incremental Inflow Options

Naturalized streamflows at each control point for each month of the simulation are provided as input data. The incremental inflow between control points is defined as the naturalized streamflow at the downstream control point minus the corresponding flow at the upstream control point(s). For example, in Figure 1, the incremental inflow between control points CP-2, CP-3, and CP-4, for a given month, is the flow at CP-4 minus the sum of the flows at the upstream CP-2 and CP-3. Since streamflow usually increases in a downstream direction, incremental inflows are typically positive. However, flows at an upstream location exceeding corresponding flows at a downstream location is not unusual. Negative incremental inflows may result from channel seepage losses between control point locations, large travel times causing the effects of precipitation events to reach adjacent control points in different time periods, and/or gaging or data input errors.

Total, rather than incremental, naturalized streamflows are provided as WRAP input. The computational algorithms are also based on total flows. As previously discussed, within the water rights loop for a given month, the amount of streamflow available to a water right is computed as the lesser of the yet unappropriated (considering all higher seniority rights) streamflows at the control point of the right and all downstream control points. For example, in Figure 1, the streamflow available to a water right at control point CP-2 is the lesser of the still unappropriated total streamflows at CP-2, CP-4, or CP-6. Thus, negative incremental inflows between CP-2 and either CP-4 or CP-6 reduce the streamflow available to water rights at CP-2. The term "negative incremental" refers to the naturalized streamflow at the downstream CP-6 and/or CP-4 being less than that at CP-2. The impact of negative incremental inflows in the computations may or may not properly represent the actual situation being modeled. Thus, WRAP3 provides optional capabilities for dealing with negative incremental inflows in the naturalized streamflow data.

This WRAP3 feature involves determining the negative incremental inflows at the beginning of the simulation computations. The negative incrementals can be used by the model to adjust the naturalized streamflows prior to the water rights simulation and/or can be written to a file for information purposes. The negative incremental inflows can be computed from the perspective of either "looking downstream" or "looking upstream."

Computations of negative incremental inflows looking downstream are identical to the computations of available streamflow within the water rights loop. The algorithm simply compares the naturalized streamflow at each control point downstream of the current control point to the naturalized streamflow at the current control point. The negative incremental inflow is the highest difference between the naturalized streamflow at the current control point and any control point physically downstream. The value of negative incremental inflow is either zero or a negative number indicating the amount that must be subtracted from the current control point to equate its naturalized streamflow to the lowest naturalized streamflow occurring below the current control point.

Computations looking upstream sum total incremental inflow at all control points above the current control point. Computations move from control point to control point, adjusting the incremental inflows in an iterative manner until no more incremental inflows are added. The resulting value at each control point is either zero or positive indicating the amount that must be added to the inflow at that control point to remove the negative incremental inflow.

WRAP3 includes four negative incremental inflow options. These options involve adjusting the naturalized streamflows prior to the system simulation and/or writing negative incremental inflow data to a file for information. The user selects one of the options listed below and also specifies whether or not a negative incremental output file is to be created. With options 1 and 2, negative incremental inflows are identified for informational purposes only with no adjustments to the WRAP simulation. Options 3 and 4 involve adjustments to the naturalized streamflows used in the simulation computations. Negative incremental inflows are computed identically the same with options 2, 3, and 4, but the computed values are used differently.

Option 1. - The default option 1 involves no adjustments to the naturalized streamflow input data. Negative incrementals are computed looking downstream for information purposes only. The user can request an output file containing zero or negative numbers representing the reduction in naturalized streamflows required at each control point for each time period to eliminate negative inflows between the control point and downstream control points. A WRAP3 option 1 simulation is the same as a WRAP2 simulation, except WRAP2 does not provide an output file alerting the user to the negative incremental inflows.

Option 2. - Option 2 also involves no adjustments to the naturalized streamflows. Thus, the simulation results are identical for WRAP3 options 1 and 2 and WRAP2. However, with option 2, negative incremental inflows are computed, for information only, looking upstream. The negative incremental inflow output file is written as zeros and positive numbers representing the increase in naturalized streamflows required at a control point to remove negative incremental inflows between it and upstream control points.

Option 3. Option 3 involves computing the negative incrementals looking upstream, just as option 2, and then adjusting the naturalized streamflows accordingly at each control point. The simulation is based on forcing all negative incremental inflows to zero.

Option 4. - Option 4 also involves computing incremental inflows looking upstream but only makes the "extra" naturalized streamflows available at the control points at which they occur.

Example. - For the river basin of Figure 1, for a given month, naturalized streamflows of 18, 20, 9, 15, 4, and 12 acre-feet occur at control points CP-1, CP-2, CP-3, CP-4, CP-5, and CP-6, respectively. Since the streamflows at certain downstream locations are less than corresponding flows at upstream locations, a situation involving negative incremental inflows exists.

Options 1 and 2 involve no adjustments to the naturalized streamflows. At the beginning of the WRAP simulation, a streamflow amount of 12 acre-feet is available to a water right at CP-2, for that particular month. Note that the naturalized streamflow at CP-6 is controlling water availability at CP-2. For option 1, the incremental inflow output file would include values of -3 ac-ft for CP-4; -8 ac-ft for CP-2; and zero for the other control points, for that month. An option 2, 3,or 4 incremental file would contain values of 14 ac-ft for CP-4; 17 ac-ft for CP-6; and zero for the other control points.

Options 3 and 4 involve adjustments to the naturalized streamflows. The flows at CP-4 and CP-6 are increased to 29 ac-ft and 33 ac-ft, respectively. For either option 3 or 4, at the beginning of the simulation, a streamflow amount of 20 ac-ft is available to a water right at CP-2. With option 3, the simulation begins with streamflow amounts of 29 and 33 ac-ft available for water rights at CP-4 and CP-6, respectively. With option 4, the simulation begins with streamflow amounts of 15 and 12 ac-ft available to water rights located at CP-4 and CP-6, respectively.

Comparison. - With options 1 and 2, the naturalized streamflow availability to water rights at a control point is reduced by negative incremental inflows occurring between that control point and either upstream or downstream control points. Thus, water availability is conservatively low in the simulation. For option 3, all negative incremental inflows are forced to zero and water availability is not reduced at all, resulting in conservatively high water availability. For option 4, streamflow availability at a control point is reduced by negative incremental inflows occurring upstream but is not affected by negative incremental inflows occurring downstream. Option 4 will be the most realistic assumption in many actual river basin modeling situations.

Counting of Basin Components

WRAP2 requires the user to input the total number of water rights, control points, and uses. For the convenience of the user, WRAP3 does not. WRAP3 does the counting internally as part of its computations. Both programs will count the number of reservoirs included in the system.

COMBINED USE WITH OTHER MODELS

Streamflow Naturalization and Synthesis

The streamflow data provided as WRAP input will typically be historical flows adjusted to remove significant man-induced effects related to reservoir construction, water use diversions, and other activities. The WRAP naturalized streamflow input data represent flows which would have occurred if man had not developed the river basin or if the water management facilities and activities reflected in the water rights data did not exist.

Homogeneous streamflow input data, representing basin conditions at a specified past, present, or future point in time, are a fundamental requirement for any type of river basin or reservoir system simulation study. Although numerous generalized reservoir system simulation models are available and widely used, development of naturalized streamflow data for input to the models is typically performed on an ad hoc study-by-study basis. Generalized computer programs and data compilation procedures for adjusting historical streamflows to remove nonhomogeneities are not widely available.

Complete series of homogeneous streamflow data covering the entire period-of-analysis at all pertinent locations are required. Missing data in the streamflow records at one location are filled in by a regression analysis with available streamflow data at pertinent nearby gage locations. Computer programs are readily available for reconstituting missing monthly data in streamflow records based on regression analysis (Wurbs *et al.* 1988). Such programs include the "HEC-4 Monthly Streamflow Simulation," developed by the USACE Hydrologic Engineering Center, and "MOSS-IV Monthly Streamflow Simulation," which is an expanded version of HEC-4 available from the Texas Water Development Board. These models also include capabilities for synthesizing sequences of synthetic streamflows of any desired length based on preserving certain statistical characteristics of the naturalized historical data.

HEC-3 and HEC-5

Several generalized computer models were used in the previously cited Brazos River Basin study (Wurbs *et al.* 1988) along with TAMUWRAP, including HEC-4 and MOSS-IV cited above and the following reservoir system simulation models available from the Hydrologic Engineering Center (HEC) of the U.S. Army Corps of Engineers.

HEC-3 Reservoir System Simulation for Conservation
HEC-5 Simulation of Flood Control and Conservation Systems

HEC-3 is somewhat similar to WRAP3. Whereas diversion requirements are met in a user-specified priority order in WRAP3, diversion requirements are met in an upstream to downstream order in HEC-3. HEC-5 has similar capabilities as HEC-3 for simulating conservation operations and much more comprehensive capabilities for simulating flood control operations. Unlike TAMUWRAP, HEC-3 and HEC-5 have no capabilities for simulating a priority water rights permit system. However, HEC-3 and HEC-5 provide capabilities not available in TAMUWRAP, particularly in regard to hydroelectric power and flood control operations. HEC-3 and HEC-5 contain options for computing firm yields in a single run of the model. Multiple simulation runs are required to iteratively compute firm yield with TAMUWRAP.

The simulation capabilities of HEC-3/HEC-5 and TAMUWRAP can be combined. Streamflow depletions and unappropriated streamflows computed with TAMUWRAP can be provided as streamflow input data for HEC-3 or HEC-5. The TAMUWRAP adjusted streamflow represents the streamflow available to specified water rights after all other water rights have been considered. Thus, HEC-3 or HEC-5 can be run with streamflow data representing only the streamflow available institutionally as well as hydrologically to the pertinent reservoir system or water management entity.

TABLES includes options for converting streamflow depletions and unappropriated flows from a WRAP output file into input records which can be conveniently incorporated into either a HEC-3 or HEC-5 input data file. The TABLES options also allow inclusion of evaporation rate records along with the streamflow records prepared for a HEC-3 or HEC-5 input data file.

WRAP INPUT AND OUTPUT DATA OVERVIEW

A WRAP (WRAP2 or WRAP3) input file contains a series of required and optional records representing the stream/reservoir/rights system being modeled. The input records also include several job control parameters that invoke various model options, such as selection of data to output. Both WRAP2 and WRAP3 will run the same basic data set with identical results. However, WRAP3 contains optional capabilities, not included in WRAP2, which require additional input data. Input data requirements are outlined below. Detailed instructions for developing the input file records are provided in Appendix A. An example is presented in Appendix C.

Both models write identical main output and error files. WRAP3 writes two additional optional output files which will be described as well. The post-processor program TABLES reads the WRAP main output file and develops data tabulations and summaries.

Units

The units for all the input data must be consistent, but any units can be used. Streamflow, diversion, and evaporation data must have consistent volume per month units which correspond to the reservoir storage volume and area units. Typical units are acre-feet for the reservoir storage and volume/month or volume/year quantities; acres for reservoir surface area; and feet for monthly evaporation rates. The naturalized streamflow and evaporation rate input data provided on IN and EV records are multiplied by factors inputted in the fourth and fifth fields of the CP records for each control point. For example, if permitted diversions and reservoir storage input data are in acre-feet and reservoir areas are in acres but mean monthly naturalized streamflows and monthly evaporation rates are inputted in second-feet-day ($ft^3/s \cdot day$) and inches, respectively, the conversion factors 1.9835 ac-ft/sfd and 0.083333 ft/inch would be entered as the multipliers in the control point (CP) records.

Several of the tables created by program TABLES include the label "acre-feet" in the headings. Thus, the headings of these particular tables will be incorrect if acre-feet is not used as the basic volume unit. Otherwise, any units can be used if kept consistent.

The variable POWFCT, entered in the fifth field of the JD record of a WRAP3 input file, is a multiplier factor used in the hydroelectric power computations, which reflects unit conversions as well as the computational time period and unit weight of water. The energy computations are based on the following equation:

$$E = \gamma QHet \text{ (unit conversion factor)}$$

or:

$$E = QHe \text{ (POWFCT)}$$

where: POWFCT = γt (unit conversion factor). POWFCT has a value of 0.0010237 if the following quantities are used:

unit weight (γ) = 62.4 lb/ft^3
time period (t) = 1 month

and the other variables in the above equation are expressed in the following units: energy (E) in megawatt-hours, discharge (Q) in acre-feet/month, and head (H) in feet. Efficiency (e) is dimensionless. The model uses a default of POWFCT = 0.0010237 if no value is entered in the fifth field of the JD record. This value is computed below for illustrative purposes. POWFCT values for other units can be determined by adjusting the values shown below accordingly.

$$\text{unit conversion factor} = (43{,}560\ \text{ft}^3/\text{ac-ft})(3.766\text{x}10^{-10}\ \text{megawatt-hr/ft-lb}) = 0.000016405$$

$$\begin{aligned}\text{POWFCT} &= \gamma t\ (\text{unit conversion factor}) \\ &= (62.4\ \text{lb/ft}^3)(1\ \text{month})(0.000016405) \\ &= 0.0010237\ \text{megawatt-hour} \cdot \text{month} / (\text{ac-ft} \cdot \text{ft})\end{aligned}$$

Input Data Records and Requirements

Each input data record begins with a two-character identifier. The records are listed by identifier in Table 4. The record types are pertinent to both WRAP2 and WRAP3, except for the OR, WI, PV, and PE records which are used only for WRAP3. Input data requirements for each type of record are discussed below.

Title Records (T1,T2,T3)

Three title records are required at the beginning of the input file. The titles, headings, and/or comments provided on the title records are reproduced at the top of each output file created by the models. The title records may be blank if desired.

Job Control Record (JD)

The JD record must follow the three title records. It contains the number of years in the simulation, the number of periods (months) per year and the year at which to start the simulation. WRAP2 requires that the user count the number of water rights, control points, and use types contained in the simulation and enter this information on the JD record. WRAP3 does not require the user to enter this information, but rather automatically makes the counts as it reads the input file. Information regarding several WRAP3 features are input on this record, including hydropower unit conversions, negative incremental inflow options, and system reservoir release decision options. The JD record also includes switches for output options.

Table 4
WRAP2 and WRAP3 Input Records

T1,T2,T3 - titles or headings
****** - comments
JG - water rights groups for output
JR - reservoirs for output
JD - job control
UC - monthly use factors
CP - control point information
WR - water right
WS - water right storage
OR - multiple-reservoir operating rules (WRAP3 only)
WI - storage/diversion table for type 4 right (WRAP3 only)
SV - storage/area table volumes
SA - storage/area table areas
PV - storage/elevation table volumes (WRAP3 only)
PE - storage/elevation table elevations (WRAP3 only)
ED - end of data for basin description
IN - naturalized streamflows
EV - net reservoir evaporation rates

Water Right Group Output Record (JG)

Many river basins will contain several hundred or thousand water rights. Computed results can be aggregated by control point and written to the output file as control points records. Control point output records represent a summation or aggregation of data for all water rights associated with the control point. The JD record includes a parameter to specify that output records be written for either all or none of the control points.

Output for each individual water right will typically not be needed for all of the rights included in a simulation. The JG record allows the user to specify the water rights for which information is written to the main output file as individual water rights records. The user may list the identifiers of up to 60 water rights on a series of JG records. At least one JG record must be entered. The list of identifiers follows an integer number in the first field of the first JG record. If it is desired to output simulation results for every water right in the system, a negative number may be entered on the JG record. If it is desired to output no information for individual water rights, a zero may be entered.

It is also possible to follow a short hand method for listing water rights for output. The identifiers in a JG record may signify water right groups. A water right is defined as part of a group if its water right identifier, control point identifier or its optional group identifier match any of the identifiers listed on a JG record. A water right's group identifier may be entered in the last field of the WR record for that right, described below. With this option, it is possible to output results for (1) an individual water right by listing its identifier on a JG record, (2) all of the water rights located at a control point by listing that control point's identifier on a JG record, and (3) all water rights that have group identifiers on the WR record matching identifiers on a JG record.

The post-processor program TABLES allows summary tables of simulation results for water rights groups to be built as well as summary tables for individual water rights. To enable TABLES to do this, the output records containing water right results must be labeled with the water right group identifiers instead of the water right identifiers. Inputing a positive number into the next to last field of the JD record will cause the group identifiers of all water rights to be output instead of the water right identifiers.

Reservoir Output Record (JR)

Output associated with each individual reservoir will often not be needed for all the reservoirs included in a simulation. Up to 60 reservoirs may be listed for output on a series of JR records. If it is desired to flag all of the reservoirs for output, a negative number may be entered in the first field of the JR record. If it is desired to output no simulation results for individual reservoirs, a zero may be entered in the first field.

The JG records must be entered before the JR records in WRAP2. WRAP3 allows either the JR or the JG records to be listed first. Both models require at least one JR and at least one JG record. If more than one of either record is listed, the entire set of that record must be entered consecutively. The JR and JG records must follow the JD record in the input file.

Monthly Use Factors Record (UC)

Each water right (WR) record includes an annual permitted diversion and a use type identifier. Selection of monthly distribution factors, provided on UC records, is the only utilization in the simulation computations of the use type identifier. UC records are required for each type of water use. The permitted annual diversion amount (or hydroelectric energy) is divided into monthly diversion requirements according to monthly use factors entered on a series of required UC records following the JG and JR records. These records include the six-character alpha-numeric use type identifier and associated set of monthly use factors. These use factors do not have to sum to unity. Both WRAP2 and WRAP3 sum the use factors and then divide each use factor by that sum to transform the use factors into decimal fractions summing to unity. Both models are currently dimensioned for 12 uses. The types of water use could be associated with particular uses, such as irrigation, municipal, industrial, and hydropower, or otherwise represent different distributions of use over the year.

Control Point Record (CP)

The control point (CP) records follow the UC records. One CP record is required for each control point. This record contains the six-character alpha-numeric identifier of the control point, the identifier of the control point immediately downstream, and two conversion factors by which to multiply the monthly evaporation rate (EV records) and naturalized streamflow (IN) data input for the control point. If either conversion factor is entered as zero or blank, the factor is defaulted to unity. Both programs are currently dimensioned for 50 control points. If a control point has no control points downstream, the identifier entered for the next downstream control point is 'OUT'.

Water Right Record (WR)

Data describing water rights are entered on a series of WR and WS records. WR records contain the six-character water right, control point, and use identifiers, identifier of the control point at which return flows reenter the stream system, priority number of the water right, annual permitted diversion, and return flow factor. WRAP3 also requires that the water right type (1,2,3 or 4 or hydropower) be entered. Several of these data have default values and various options associated with them.

If return flows reenter at the control point directly downstream, the return flow control point identifier field may be left blank. The return flow control point may also be listed as the control point location of the water right itself if desired. If the water right returns flow out of the basin, then the return flow location identifier should be listed as 'OUT', or a zero return flow factor should be entered.

The return flow factor is the decimal fraction of the diversion met for a water right that is returned to the river system. The return flow factor may be entered as a number greater than unity if desired. This will allow a water right to "import water" into the basin by returning a higher amount than it diverted. A user option allows the return flows to reenter the stream system during either the same month or the next month after the diversion. The next month option is activated by entering a negative sign before the return flow factor.

If a hydroelectric power right is specified, the annual energy requirement is input in the place of the permitted annual diversion. Energy requirements for multiple hydropower rights must be entered as cumulative in order of priority. A hydropower right must have an energy requirement that is equal or higher then any senior hydropower right associated with a reservoir. WRAP2 contains no hydropower capabilities.

It is possible for several rights to have the same priority number. If the priority number is the same for two or more rights, priority is assigned in the order that the water rights are entered in the input file.

Water Right Reservoir Storage Record (WS)-WRAP2

If a water right includes storage capacity at a reservoir, a WS record must follow the WR record. A WRAP2 right is allowed to refill storage and make withdrawals from only one reservoir. The required data on the WS record includes the reservoir identifier and the permitted storage capacity of the right. The storage capacity is the total cumulative active storage level to which the reservoir can be filled under the water right. Several water rights may be associated with a single reservoir, each with a different storage capacity. The storage capacities must be cumulative according to the priority of the water rights. A junior right is required to have a storage capacity at a reservoir equal to or greater than the storage capacity of any other more senior rights associated with that reservoir.

The control point of the first right to be associated with a reservoir is assumed to be the location of the reservoir. Care should be taken to ensure that all other rights associated with the reservoir be located at that control point as well. The storage-area data is provided with the first water right at a reservoir and not repeated for subsequent rights at the same reservoir. Coefficients for the storage-area function are entered in the WS record. A negative entry for the first coefficient indicates that a storage-area table will follow on SV and SA records.

Water Right Storage Record (WS)-WRAP3

In WRAP3, a water right can be associated with up to 50 reservoirs with WS records for each reservoir following the WR record. One reservoir, called the primary reservoir, is analogous to a WRAP2 reservoir. Only the one primary reservoir is allowed to refill storage. The water right diversion and primary reservoir must be located at the same control point. Type 1 and hydropower rights are the only water right types allowed to refill storage. A type 1 right or hydropower right may have either zero or one primary reservoir and up to 50 secondary reservoirs. The primary reservoir must be cited on the WS record immediately following the WR record. All reservoirs on the second and subsequent WR records are termed secondary reservoirs and can only make releases for the water right, not be refilled by it. All reservoirs associated with type 2, 3, or 4 rights are classified as secondary reservoirs.

The WRAP3 WS record includes fields for the inactive storage capacity, storage content at the beginning of the simulation, tailwater elevation for hydropower computations, and hydropower plant efficiency. For nonhydropower rights, designation of lakeside diversions on the WS record allows hydroelectric power turbines, associated with a more junior hydropower right, to be bypassed. By default, all diversions and releases from a reservoir are assumed to contribute to power generation for junior hydropower rights at the reservoir, unless otherwise specified. Hydroelectric power can be generated only at a primary reservoir. If the field for beginning-of-simulation storage content is left blank, the reservoir is assumed to start the simulation full to its maximum capacity.

Multiple-Reservoir Operating Rules Record (OR)-WRAP3

If two or more reservoirs are associated with a water right, an OR record must follow each WR record to define the multiple-reservoir operating rules. An OR record can also be provided for a single secondary reservoir associated with a water right, if needed to either specify the control point location or to flag pipeline conveyance. The OR record includes the reservoir control point, storage capacity at top of zone 2 (bottom of zone 1), zones 1 and 2 release priority factors, and the gravity flow versus pipeline switch. The control point identifier is not required if already provided by a previous WR or OR record. The reservoir zones and weighing factors are defined in the discussion of multiple reservoir release rules on pages 16-20.

If the last field of the OR record is blank or zero, reservoir operation is based on assuming conveyance by gravity flow in river channels. Reservoir releases can meet diversion requirements at the control point of the reservoir or at any control point located downstream of the reservoir. If the OR record has a negative integer in the last field, this constraint is removed. A pipeline or canal, with pumps as needed, is assumed to convey water from the reservoir to the control point of the water right diversion.

Storage-Diversion Table for a Type 4 Right (WI)-WRAP3 only

Immediately after a WR record defining a type 4 right, a set of up to 12 pairs of data representing the required diversion amount as a function of storage must be entered. Note in Appendix A that data is not entered in the same format as storage-area or storage-elevation data. The storage volumes represent the total volume contained in all of the reservoirs associated with the right. The diversion amounts represent the permitted diversion amount of the right at any given storage level. Permitted diversion values are obtained from linear interpolation of the table.

Storage-Area Records (SV,SA)

For each reservoir flagged by a negative number in the WR record in the field of the first storage-area coefficient, a set of two SV and two SA records is required at the end of the water right data. The records may contain up to 12 pairs of data that define the storage volume versus surface area relationship for the reservoir. The SV and SA records represent the storage volume and corresponding area, respectively. The data should be entered from low to high with both SV records entered before the SA records. The corresponding reservoir identifier must be entered on the first SV record. The programs are dimensioned to allow up to 50 storage-area tables to be input. The sets of SV and SA records are grouped together at the end of all the WR and WS records.

The storage volume versus water surface area relationship for a reservoir with inactive storage may be defined differently in WRAP2 and WRAP3. WRAP3 allows explicit designation of an inactive pool, but WRAP2 does not. For WRAP2, an active storage versus area relationship is entered as input data. For a reservoir with inactive storage, a positive nonzero area will be associated with zero active storage. For WRAP3, if a nonzero inactive (bottom of active pool) storage is entered, a total storage (inactive plus active) versus area relationship is required. The WRAP3 and WRAP2 storage/area relationships are identical if the value of inactive storage (bottom of active pool) is entered as zero in WRAP3. This discussion is equally pertinent for storage-area relationships expressed as coefficients on a WS record or as a table on SV and SA records.

WRAP3 allows the reservoir level to be drawn down below the bottom of the active pool (top of inactive pool) by evaporation. WRAP2 does not. However, if a positive area is associated with zero storage, WRAP2 allows evaporation to deplete streamflow even if the active storage capacity is empty.

Hydropower Storage-Elevation Records (PV,PE)-WRAP3 only

Each reservoir associated with a hydropower right requires a set of two PV and two PE records at the end of the water rights data. The records may contain up to 12 pairs of data that define the storage versus water surface elevation relationship for the reservoir. The PV records represent the storage volume, the PE records represent the corresponding water surface elevation. The elevation data should not be adjusted to account for tailwater elevation. A constant tailwater elevation is entered on the WS record for the water right. The data should be entered from low to high with both PV records entered before the PE records. The corresponding reservoir identifier must be entered on the first PV record. The data are entered identically to storage-area records and may be entered anywhere after the water rights data records and before the end of data record.

End of Data Record (ED)

After the necessary data describing the stream/reservoir/rights system components have been entered, an end of data record must be entered prior to entering the inflow and evaporation data.

Streamflow Record (IN)

Naturalized streamflow data for each control point is entered for each month of each year of the simulation on a series of IN records. Each control point will have one or more IN records containing a year's worth of inflow data. The first IN record must contain the control point identifier, the year, and the first six months' naturalized streamflow. The naturalized streamflow input for each month represents the cumulative streamflow during that month. If the inflow is identical for two or more control points, a negative year may be entered on the second IN record with the identifier of the control point for which flows have been entered previously. The inflows at the control point will be set equal to the inflows of the previously entered control point. If unit conversions are required, the inflow data entered for each control point will be multiplied by the inflow multiplication factor listed on the CP record for each control point. The IN record repetition and CP record multiplier features also allow naturalized streamflows at a control point to be computed by multiplying the streamflow input data at that or another control point by a factor such as a drainage area ratio. All inflow records for a year must be entered consecutively. Control points within each year's block of IN records may be entered in any order.

Reservoir Evaporation Rate Record (EV)

Evaporation data for each control point containing a reservoir is entered similarly to inflow data. Each year's evaporation records must be entered after the inflow records. The evaporation data listed represents the net monthly evaporation rate specified as a depth. The evaporation data listed for each control point will be multiplied by the evaporation rate multiplication factor listed on the CP record for the control point. Unit conversions as well as conversion from pan evaporation rates may accomplished with these factors. Control points within each year's block of EV records can be entered in any order.

Comment Record (**)

Comment records delineated by a double asterisk may be entered anywhere within the input data after the first three title records (T1,T2,T3) and before the end of data record (ED). The comments or notes are for information only and are not read or used in any way by the model.

Output Data Description

WRAP2 produces a simulation output file and an error message file. WRAP3 creates these same two output files plus two additional optional files. The WRAP output files include:

- error message file (WRAP2 and WRAP3)
- main simulation output file (WRAP2 and WRAP3)
- system release/hydropower file (WRAP3)
- inflow adjustment file (WRAP3)

Program TABLES reads the main WRAP simulation output file and system release/hydropower file and develops data tabulations and summaries. Some additional simple computations, such as computing reliability statistics, are performed by TABLES in conjunction with organizing and presenting the WRAP simulation results. Program TABLES is discussed in detail in a later section. TABLES does not use the other two files in any way. They are written for informational purposes only and may be read or printed out by the user.

Error File (WRAP2 and WRAP3)

The data input routine contains several data checks that take place as the data is read from the input file. Fatal errors, such as missing required records, cause the program to terminate. If a fatal input data error is encountered, an appropriate message is written to the screen and an identical message is written to the error file before program termination. Several non-fatal errors which may occur during program execution have been defined as well. Non-fatal errors will cause an appropriate message to be written to the error file, but the program will not terminate. A common non-fatal error might be a reservoir evaporation computation not iterating to sufficient precision. The data causing the error will customarily be written to the error file for the user to check.

Output File (WRAP2 and WRAP3)

The WRAP2 and WRAP3 output file is outlined in Table 5. The file contains the simulation results for each control point and for whichever water rights and reservoirs have been flagged for output. As indicated in Table 3, the data are written, as the computations proceed, on a month-by-month basis, with water right data written in order of priority. The format of this file is designed to compactly store the voluminous output data in the order in which it is computed. Although the file can be viewed directly by the model user, the format is not convenient for interpreting simulation results. Program TABLES provides the capability to reorganize, tabulate, and summarize the simulation results in a variety of formats.

The output file begins with four title lines; the first line identifies the file as a WRAP2 or WRAP3 file, and the remaining three lines are the title records from the input file. The fifth line of the output file contains, from left to right, the year on which the simulation started, the number of years of the simulation, the number of periods per year, the number of control points in the basin, the number of water rights output and the number of reservoirs output. The simulation results are then written in a columnar format in blocks of data representing each month of the simulation. Within each month of simulation results, output records for the chosen water rights are written first, followed by the control point output records, followed by the output records for the chosen reservoirs. The content of the individual records is described below. Any differences between WRAP2 and WRAP3 are identified where appropriate.

Table 5
WRAP2 or WRAP3 Output File

First Five Records of WRAP Output File

```
WRAP3 (MARCH 1993 VERSION) OUTPUT FILE
TITLE1
TITLE2
TITLE3
YRST NYRS NPRDS NCPTS NWROUT NREOUT
```

Block of Records Repeated for Each Period (Month)

water rights output records	(number of records = NWROUT)
control point output records	(number of records = NCPTS)
reservoir/hydropower output records	(number of records = NREOUT)

Definition of Variables on Fifth Record

YRST	- first year of simulation
NYRS	- number of years in simulation
NPRDS	- number of periods in a year (12 assuming a monthly interval)
NCPTS	- number of control points in WRAP output file
NWROUT	- number of water rights in WRAP output file
NREOUT	- number of reservoirs in WRAP output file

Total Number of Records in WRAP Output File

number of records = 5 + (NYRS*NPRDS) * (NWROUT + NCPTS + NREOUT)

Water Rights Output Records

Each record provides data for a water right for a given period (month). The records for all of the water rights are grouped together for a given period. The 80 character record contains 10 variables stored in the format indicated below. Releases from other reservoirs (item 8 below) can be nonzero only for a WRAP3 multiple-reservoir water right. This field is always zero in a WRAP2 output file.

FORMAT (A6, 5F9.1, F10.1, F9.1, 2X, 2I4)

1.	water right identifier	(A6)
2.	diversion shortage	(F9.1)
3.	permitted target diversion	(F9.1)
4.	evaporation	(F9.1)
5.	end-of-period storage	(F9.1)
6.	streamflow depletion	(F9.1)
7.	available streamflow	(F10.1)
8.	releases from other reservoirs	(F9.1)
9.	year	(I4)
10.	month	(I4)

Table 5 Continued
WRAP2 or WRAP3 Output File

Control Point Output Records

Each record provides data for a control point for a given period (month). The records for all the control points are grouped together for a given period. The 80 character record contains nine variables stored in the format indicated below. A control point record contains data summed for all the water rights located at the control point or data, such as naturalized and unappropriated streamflows, not associated with a particular water right. Return flows are cited at the control point at which the flows reenter the stream.

FORMAT (A6, 5F9.1, F10.1, F9.1, F10.1)

1.	control point identifier	(A6)
2.	diversion shortage	(F9.1)
3.	permitted diversion	(F9.1)
4.	evaporation	(F9.1)
5.	end-of-period storage	(F9.1)
6.	streamflow depletion	(F9.1)
7.	unappropriated streamflow	(F10.1)
8.	return flow	(F9.1)
9.	naturalized streamflow	(F10.1)

Reservoir/Hydropower Output Records

Each record provides data for a reservoir and/or hydroelectric power plant for a given period (month). All the reservoir/hydropower records are grouped together for a given period. The 80 character record contains nine variables stored in the format indicated below. The variables related to hydroelectric power generation are always zero in a WRAP2 output file. WRAP3 may output records for reservoirs with or without hydroelectric power.

FORMAT (A6, 2F10.1, 6F9.1)

1.	reservoir identifier	(A6)
2.	hydroelectric power shortage (+) or secondary energy (-)	(F10.1)
3.	energy generated	(F10.1)
4.	reservoir evaporation	(F9.1)
5.	end-of-period storage	(F9.1)
6.	inflows to reservoir from streamflow depletions	(F9.1)
7.	inflows to reservoir from releases from other reservoirs	(F9.1)
8.	releases from reservoir accessible to hydroelectric power turbines	(F9.1)
9.	releases from reservoir not accessible to hydroelectric power turbines	(F9.1)

Water right output records. Each water right output record contains, from left to right, the water right or group identifier, the diversion shortage that occurred, the monthly permitted diversion amount, the evaporation volume that occurred if the right is associated with a reservoir, the end-of-period storage of the reservoir, the streamflow depletion the water right made during the month, the streamflow available to the right before the streamflow depletion, all water that was released from secondary reservoirs to meet the diversion and/or refill storage, and the year and month of the simulation.

The difference between the permitted diversion and the diversion shortage represents the diversion amount actually met from streamflow depletions and reservoir releases. Both are written as zero or positive. The values of permitted diversion and diversion shortage for a hydropower right are written as zero.

The evaporation and end-of-period storage represent the values that would occur assuming no other junior rights are associated with the reservoir. The reservoir evaporation will be written as a negative number if a negative net evaporation rate occurred at the control point. The values written for the most junior right at the reservoir are therefore the actual values that occur for the reservoir. Any values written for senior rights at the reservoir are intermediate values only.

The streamflow depletion represents the streamflow that the water right appropriated to meet the permitted diversion amount and/or refill storage and meet evaporation. In months with a negative net evaporation rate, the streamflow depletion may be written as a negative number. In this case, the water right actually makes water available to the basin by catching precipitation that falls onto the reservoir surface.

In WRAP3, the value for reservoir releases includes only releases from secondary reservoirs to meet the storage and permitted diversion requirements of the right. The amount that is released from the primary reservoir is not included. The value of releases from system reservoirs is always zero in WRAP2 output files.

Control point output records. Control point records provide a summation of output data for all the water rights at each control point and are similar in format to water right output records. Each record contains, from left to right, the control point identifier, the sum of the shortages and permitted diversions for all water rights, evaporation and end-of-period storage for all reservoirs, and streamflow depletions for all rights located at the control point. The final three fields contain the unappropriated flow remaining at the control point after all streamflow depletions have been made, the sum of the return flow returned at the control point from the current and previous month, and the naturalized streamflow at the control point.

Reservoir/hydropower output records. Reservoir output records include, from left to right, the reservoir identifier, power shortage at the reservoir, energy produced at the reservoir, evaporation, end-of-period storage, streamflow depletions made available to the reservoir, releases from other reservoirs made available, releases from the reservoir through the outlet works and lakeside releases from the reservoir.

The hydroelectric energy produced at the reservoir in each month is calculated from the average water surface elevation of the reservoir, the total flow through the outlet works for all rights associated with the reservoir, and the tailwater elevation input for the most junior hydropower right associated with the reservoir. The power produced is computed assuming that the turbine capacity is unlimited. Hydropower shortages are calculated as the algebraic difference between firm power and the power produced at the reservoir. Positive shortage values signify that insufficient water was released from the reservoir through the outlet works to produce the firm power of the most junior hydropower right at the reservoir. Negative shortages represent "secondary energy" that was produced by releases through the outlet works to meet water right diversion and storage requirements, assuming unlimited turbine capacity. The hydropower values are output as zero in a WRAP2 simulation.

Streamflow depletions made available to a reservoir include depletions for diversions as well as depletions to refill storage and meet evaporation. Depletions for diversions are assumed to enter a primary reservoir and then are released either lakeside or through the reservoir's outlet works.

Releases made by a reservoir include both releases as a primary reservoir and releases as a secondary system reservoir. The releases written to a reservoir output record include both primary and secondary releases. WRAP2, allowing only primary releases and containing no hydropower capabilities, makes no distinction between lakeside or outlet work releases. WRAP2 releases are written as outlet work releases by convention.

System Release/Hydropower File (WRAP3)

The system release file written by WRAP3 lists the releases from the primary and secondary reservoirs for each month of the simulation for each water right chosen for output. The file also writes the firm energy and the energy produced by each water right. The release from a primary reservoir is simply the diversion met by the right. This amount may include water from streamflow depletions and water released from secondary reservoirs as well as water taken from storage in the primary reservoir.

The data for each right is written as a single record in the following order:

- water right or water right group identifier,
- number of reservoirs associated with the right,
- year and month,
- energy target and energy generated,
- and reservoir identifiers and associated releases listed in the same order as the WS records in the input file.

The energy target and energy generated are written as zero for non-hydropower rights. This is the only information available regarding the energy generated by senior rights when several rights generate energy at the same reservoir. The system release/hydropower file is read by program TABLES to develop tables of system reservoir releases for a water right or water right group.

Inflow Adjustment File (WRAP3)

If specified on the job control (JD) record, the information obtained by the different options for computing negative incremental inflows is written for each control point for each month of the simulation. Data is written for each control point a year at a time. Depending upon the option chosen, the data written for each control point is either negative, zero or positive, indicating the amount that must be added to or subtracted from the inflows to remove the negative incremental inflow.

PROGRAM TABLES

The computer program TABLES reads the WRAP (WRAP2 or WRAP3) input and output files, performs various data manipulations, and develops output tables and data listings. The WRAP output data, as well as input data, is quite voluminous. TABLES provides convenient and flexible capabilities for data organization, tabulation, and presentation.

Files

An execution of TABLES begins with an interactive routine in which the user provides file names for all pertinent files, which may include:

TABLES input file
TABLES output file
WRAP (WRAP2 or WRAP3) input file
WRAP (WRAP2 or WRAP3) output file
WRAP3 system release/hydropower file

The TABLES input file specifies the tables and data listings to be developed. The tables and data listings are stored in the TABLES output file. The data from which the tables and data listings are compiled are read from WRAP input and/or output files. The TABLES input and output files are always named and opened. One or more WRAP input or output files are required depending on the types of tables or data listings specified in the TABLES input file.

Program Organization

TABLES consists of a main program and several subroutines. The main program opens the required files, checks the identifier on each record of the TABLES input file in turn, and calls the appropriate subroutines. The WRAP input and output files are read and the specified tables and data listing are developed and written to the TABLES output file by the subroutines. Each subroutine is associated with a specific type of table or data listing.

A majority of the TABLES input records activate subroutines which simply rearrange and tabulate, with appropriate table headings, selected data read from the WRAP input or output file. However, some of the subroutines also include simple computational algorithms. In some cases, summing or other arithmetic combining of data are involved. Other subroutines include a little more complex arithmetic operations. For example, a 1SRT record calls a subroutine containing a water rights sorting algorithm. A 2REL record involves computing period and volume reliabilities. A 2PER record activates a subroutine which converts reservoir storages from volume units to percentages of storage capacity and also develops a storage/duration table.

TABLES Input File

The tables or data listings to be developed are specified in a TABLES input file. Each type of table or data listing is associated with the selected four-character record identifier. Each record in the TABLES input file begins with a four-character record identifier, followed by parameters providing instructions associated with that particular type of table or data listing. All records are optional; there are no required records. No limits are placed on the number or order of the records, with the exception of TITL records which are limited to a maximum of five records and must be located at the beginning of the input file. Any number of each type of record, except the TITL records, can be placed in any order in the input file. TABLES reads one record of the input file; develops the tables and data listings specified by the input record; stores the tables and data listings in the TABLES output file; and then goes on to the next record of the input file. TABLES input records are listed in Table 6 and discussed below. Detailed instructions for developing a TABLES input file are provided in Appendix B. The example problem in Appendix C illustrates the format and headings for several types of output tables.

Miscellaneous Records

TITL records provide titles or headings to be reproduced on the cover page and at the top of each job type 2 or 3 table. Zero to five TITL records may be used.

COMM records provide a means to insert comments or notes at any location in the input file. COMM records are not read or used in any way by the program.

The ENDF record denotes the end of the input file. Any records following the ENDF record will not be read. Although an ENDF record is not required, a message is printed on the terminal screen, as a reminder, if the input file has no ENDF record.

Job Type 1 Records

1REC, 1SUM, and 1SRT records specify listings and tabulations of data which are read from a WRAP input file. Inclusion of a 1REC record in a TABLES input file results in a listing of specified WRAP input records. The 2-character identifiers of the WRAP input records to be included (or alternatively to be omitted) in the listing are entered on the 1REC record.

A 1SUM record results in a summary table of water rights data by control point, type of use, water right type, or water right group. This table includes number of rights, diversion amounts, number of reservoirs, storage capacity, and range of priorities.

A 1SRT record requests a listing of water rights sorted in priority order or alternatively a listing sorted by type of use, control point, water right type, or water right group in priority order.

Job Type 2 Records

Job type 2 records result in tables being developed from the data contained in the water right, control point, and reservoir/hydropower records of a WRAP output file, as listed in Table 5. A WRAP output water right record contains data for an individual water right. A control point record contains data summed for all the water rights located at the control point or data, such as naturalized or unappropriated flows, not associated with a particular water right. A reservoir/hydropower record contains data for a reservoir including

Table 6
Program TABLES Input Records

Miscellaneous Records

TITL - titles or headings
COMM - comments
ENDF - end of input data file

Job Type 1 Records - Tabulations from WRAP2 or WRAP3 Input File

1REC - listing of specified input records
1SUM - water rights summary by control point or type of use
1SRT - listing of water rights sorted by priority, type of use, control point, or water right type

Job Type 2 Records - Tabulations from WRAP2 or WRAP3 Output File

2SCP - summary table for a control point
2SWR - summary table for a water right
2SRE - summary table for a reservoir
2SGP - summary table for a water right group
2SUM - summary table of summation of selected water rights
2SBA - summary table for river basin (all control points)
2REL - reliability and shortage summary
2NAT - naturalized streamflows
2UNA - unappropriated streamflows
2DEP - streamflow depletions
2SHT - shortages
2STO - reservoir storages
2PER - percentage storage of selected reservoirs and storage-duration for selected reservoirs

Job Type 3 Records - Develop IN and EV Records in HEC-3 or HEC-5 Format

3NAT - IN records of naturalized streamflows with or without EV records
3UNA - IN records of unappropriated streamflows with or without EV records
3DEP - IN records of streamflow depletions with or without EV records
3HEC - IN records of naturalized streamflows, unappropriated streamflows, streamflow depletions, or the summation of streamflow depletions plus unappropriated flows, for selected control points and selected water rights, with or without EV records

Job Type 4 Records - Tabulations from System Release/Hydropower File

4SWR - system reservoir releases for selected water rights
4SGP - system reservoir releases for selected water rights groups

hydroelectric energy generation data if a power plant is located at the reservoir.

2SGP, 2SCP, 2SWR, and 2SRE records result in summary tables for specified water right groups, control points, water rights, or reservoirs, respectively. These tables consist of either a monthly or annual tabulation of all the data items contained on the WRAP control point, water right, or reservoir/hydropower records.

A 2SUM record results in a summation of the data on the WRAP water rights output records of specified water rights. The 2SUM output table, for the summation of data for several selected water rights, has the same headings and format as the 2SWR table for a single water right. If group identifiers are output instead of water right identifiers, a 2SUM output table is identical to a 2SGP table.

A 2SBA record results in a basin summary table, with the same headings and data as the 2SCP record cited above, with the tabulated data (except naturalized and unappropriated streamflows) being the summation of the data for all the control points. The naturalized and unappropriated streamflows in the 2SBA table are the maximum of the values found at the control points.

2REL record calls for a table containing period and volume reliabilities and a shortage summary for either selected water rights, water right groups, control points, or hydroelectric power reservoirs. Three separate 2REL records would be used to obtain three separate reliability and shortage tables for selected water rights, control points, and hydroelectric power reservoirs, respectively. Period reliability is the number of months for which shortages occurred divided by the total number of months in the simulation. Volume reliability is the total volume of shortages (or total energy shortage) divided by the corresponding total permitted diversion volume (or permitted firm energy). The shortage summary is expressed in terms of the number of months and the number of years during the simulation during which the water right diversion shortage, or hydroelectric energy shortage, equalled or exceeded specified percentages of the permitted diversion or hydroelectric energy target.

2NAT, 2UNA, 2DEP, 2SHT, and 2STO records are associated with tables of naturalized streamflows, unappropriated streamflows, streamflow depletions, shortages, and end-of-period reservoir storages, respectively. The tables include one line for each year of the simulation, with each line containing the year, 12 monthly (January through December) values of the variable, and the total for the year.

The 2PER record tabulates end-of-period reservoir storage as a percentage of a user-specified storage capacity. This table is particularly useful for reviewing simulation results for multiple-reservoir system operations. The WRAP3 multiple-reservoir system release rules are based on balancing percent depletions of specified storage zones. A storage-duration table is also developed in terms of the percentage of months for which the storage content equalled or exceeded specified percentages of storage capacity. Sets of 2PER records are used to specify the reservoirs to be included in the tabulation and, for each reservoir, the storage capacities (C_1 and C_2) at the top and bottom, respectively, of the conservation pool or zone. The end-of-period storages (S) are read from the reservoir/hydropower record of the WRAP output file. The storage percentages in the 2PER table are computed as follows:

$$\text{percent storage} = ((S-C_1)/(C_2-C_1))*100\%$$

Job Type 3 Records

3HEC, 3NAT, 3UNA, and 3DEP records convert naturalized streamflows, unappropriated streamflows, streamflow depletions, and unappropriated flows plus streamflow depletions, from a WRAP output file, and evaporation rates, from a WRAP input file, to IN and EV records for inclusion in a HEC-3 or HEC-5 (USACE, Hydrologic Engineering Center 1981 & 1982) input data file. Job type 3 records also facilitate combining TAMUWRAP with a salt concentration simulation model presently being developed at TAMU, which also uses the HEC-3 type input data format.

HEC-3 has a single fixed format for the IN and EV records. HEC-5 allows several optional formats for the individual IN or EV records, including the option of using the "HEC-3" format. However, the arrangement or order of the IN and EV records, for multiple years and control points, are different between HEC-3 and HEC-5. TABLES creates each individual IN or EV record in the "HEC-3" format, which can be used in either HEC-3 or HEC-5. Each record contains the record identifier (IN or EV), control point or reservoir identifier, year, and 12 monthly streamflow or evaporation rate values for the specified year and location. The Fortran format is (A2,I4,I2,12F6.0). TABLES options allow the IN and EV records, for multiple years and locations, to be arranged in either HEC-3 or HEC-5 order. With HEC-3 format, the IN records for all control points are grouped by year. The EV records for all reservoirs for a given year follow the set of IN records for that year. With HEC-5 format, all the IN records for all years are grouped together for a given control point followed by a set of IN records for all years for the next control point, and so forth. The EV records are grouped together at the end of the set of all IN records. Options are provided on each of the job type 3 records for either including or omitting the evaporation rate (EV) records. Inputted multiplier factors can be used for converting units for the streamflow and evaporation rate data. The inflow (IN) records created by TABLES may contain either of the following:

- summation of streamflow depletions for specified water rights plus unappropriated flows at the corresponding selected control points (3HEC record)
- unappropriated flows at selected control points (3HEC record)
- summation of streamflow depletions for specified water rights (3HEC record)
- naturalized streamflows for selected control points (3HEC record)
- naturalized streamflows for all control points (3NAT record)
- unappropriated flows for all control points (3UNA record)
- summation of streamflow depletions for all water rights at all control points (3DEP record)

A 3NAT record creates IN records containing the naturalized streamflows read from the WRAP output file for all control points. Options specify either HEC-3 or HEC-5 format and either include or omit the EV records. The control point identifier placed on the IN records is assigned as integers starting with one (1,2,3, ...) in the order in which the control points records are arranged in the WRAP output file. The reservoir identifiers placed on the EV records are likewise assigned as integers starting with one (1,2,3,...) in the order in which the EV records are arranged in the WRAP input file. 3UNA and 3DEP records are identical to the 3NAT record except unappropriated flows (3UNA record) or the total streamflow depletions at each control point (3DEP record) are written on the IN records instead of naturalized streamflows (3NAT). Only one TABLES input record is required to create IN and EV records for all the control points.

A set of 3HEC records can be used to develop any output file which can be created with either a 3NAT, 3UNA, or 3DEP record as well as providing other features not available with these records. 3HEC records provide greater flexibility, but a separate record is required for each control point. A set of 3HEC records consists of an initial 3HEC record providing general specifications, followed by a specific 3HEC for each control point for which output is desired. 3HEC records provide the only mechanism, within TABLES, for adding the unappropriated flows to the streamflow depletions at a control point. 3HEC records also allow the user to specify each of the individual control point or reservoir identifiers to be written on the outputed IN and EV records. With 3HEC records, the user selects the control points and/or water rights for which streamflow data is output as IN records and the evaporation rate data to include in the associated EV records.

The EV records are read from a WRAP input file. The set of EV records for each year must be in the same order by control point. TABLES numbers (1,2,3,...) the EV records by control point in the order found in the WRAP input file, for purposes of identifying the EV records associated with each 3HEC record. The user specifies the appropriate EV control point identifier or counter (EVCT) on the 3HEC record for the control point. With a 3NAT, 3UNA, or 3DEP record the "n" sets of EV records are assigned, in order, to the first "n" control points for which IN records are provided. If there are IN records for more control points than EV records, the last control points will not be assigned EV records. Thus, 3HEC records (rather than a 3NAT, 3UNA, or 3DEP record) are required if a simple one-to-one correspondence does not exist between EV control points and IN control points entered in the same order in the WRAP input file.

WRAP input data can include a "negative year" to indicate that IN or EV records for one control point are being repeated for another. TABLES reads all streamflow data, including naturalized streamflows, from a WRAP output file. Thus, all WRAP manipulations of streamflow data, including control point repetition of naturalized streamflows, are properly reflected in the TABLES output. However, TABLES does not allow automatic repetition, for multiple control point locations, of EV records read from a WRAP input file. The user must assign EV records to control points on the 3HEC records. Unless the variable "NEGYR" on the 3HEC record is flagged, the TABLES output file will include a message written each time a "negative year" is read on a WRAP EV input record.

APPENDIX A

DESCRIPTION OF INPUT RECORDS FOR WRAP2 AND WRAP3

DESCRIPTION OF INPUT DATA RECORDS FOR WRAP2 AND WRAP3

The first two characters of each record consist of the record identifier. The records are arranged in an input file in generally the same order as cited below. The records have a maximum length of 80 characters. The title and comment records (T1, T2, T3, **) include the two-character identifier and a 78-character alphanumeric (AN) field. All other records are divided into 11 fields, some of which may not be used for a particular record. The first field is the two-character record identifier. The second field has a width of 6 characters. All other fields have a width of 8 characters. Variables with integer (I) or character (A) format specifications must be right-justified in the appropriate field. Real (F format) variables must either include the decimal or be right-justified.

T1, T2, or T3 Record - Titles or Headings - Required - WRAP2, WRAP3

field	variable	format	value	description
1	CD	A2	T1,T2,T3	record identifier
2	TITLE1 TITLE2 TITLE3	A78	AN	title or heading

** Record - Comments - Optional - WRAP2, WRAP3

field	variable	format	value	description
1	CD	A2	**	record identifier
2	-	A78	AN	comment

JD Record - Job Control - Required - WRAP2

field	variable	format	value	description
1	CD	A2	JD	record identifier
2	NYRS	I6	+	number of years in simulation
3	NPRDS	I8	+	number of periods (months) per year
4	YRST	I8	+	year in which to start simulation. All IN and EV records prior to YRST will be skipped.
5	NCPTS	I8	+	number of control points listed on CP records
6	NWRTS	I8	+	number of water rights listed on WR records
7	NUSES	I8	+	number of use types listed on UC records

JD Record - Job Control - Required - WRAP3

field	variable	format	value	description
1	CD	A2	JD	record identifier
2	NYRS	I6	+	number of years in simulation
3	NPRDS	I8	+	number of periods (months) per year
4	YRST	I8	+	year in which to start simulation. All IN and EV records prior to YRST will be skipped.
5	POWFCT	F8.0	BLANK,0	Default value of 0.0010237 will be used for multiplication factor when computing hydroelectric energy.
			+	hydropower multiplication factor
6	ADJINC	I8	BLANK,0,1	negative incremental inflow option 1
			2	option 2
			3	option 3
			4	option 4
7	STOFLG	I8	BLANK,0	end-of-period storage used when making system release decisions from secondary reservoirs.
			1	beginning-of-period storage used
8	GPOUT	I8	BLANK,0	water right identifiers output for chosen water rights
			1	group identifiers output for chosen water rights
9	ADJOUT	I8	BLANK,0	negative incremental streamflow adjustment file will not be written
			1	file will be written
10	SYSOUT	I8	BLANK,0	system release/hydropower file will not be created
			1	output file is written
11	CPOUT	I8	BLANK,0	control point records are written to the main output file
			1	control point records are not written to output file

JG Record - Water Right Groups for Output - One Required - WRAP2, WRAP3

field	variable	format	value	identifier
1	CD	A2	JG	record identifier
2	NGOUT	I6	BLANK,0	no water rights will be output
			-1	all water rights will be output
			1-60	number of water right group identifiers listed on JG records, five on each record
3-7	GROUP(1,5)	5A8	AN	identifiers of water rights and groups for output. Field 2 is blank for the second and subsequent JG records.

JR Record - Reservoirs for Output - One Required - WRAP2, WRAP3

field	variable	format	value	identifier
1	CD	A2	JR	record identifier
2	NREOUT	I6	BLANK,0	no reservoirs will be output
			-1	all reservoirs will be output
			1-60	number of reservoir identifiers listed on JR records, five on each record
3-7	REOUID(1,5)	5A8	AN	reservoir identifiers for output. Field 2 is blank for the second and subsequent JR records.

UC Record - Monthly Use Factors - One Required - WRAP2, WRAP3

field	variable	format	value	description
1	CD	A2	UC	record identifier
2	USEID(I)	A6	AN	identifier of use type
3-8	PDUSCF(I,J=1,6)	6F8.0	+	monthly use coefficients. Six entered on first UC record, six on second. Field 2 is blank on second UC record.

Index I goes from 1 to NUSES. J index goes from 1 to 12.

CP Record - Control Point Information - One Required - WRAP2, WRAP3

field	variable	format	value	description
1	CD	A2	CP	record identifier
2	CPID(I,1)	A6	AN	control point identifier
3	CPID(I,2)	A8	AN	identifier of next downstream control point
			' OUT'	no control points are downstream
4	CPDT(I,1)	F8.0	BLANK,0	no inflow multiplier will be used for inflows at this control point.
			+	factor to multiply inflows listed on IN records
5	CPDT(I,2)	F8.0	BLANK,0	no evaporation multiplier used
			+	evaporation multiplier.

Index I goes from 1 to NCPTS.

WR Record - Water Right Record - One Required - WRAP2

field	variable	format	value	description
1	CD	A2	WR	record identifier
2	FILEID(I,1)	A6	AN	water right identifier
3	FILEID(I,2)	A8	AN	control point identifier
4	FILE11(I,1)	F8.0	0,+	annual permitted diversion
5	FILEID(I,3)	A8	AN	use type identifier
6	DATE(I)	I8	+	priority number/date
7	NONE	8X	-	blank field

8	FILE11(I,5)	F8.0	+	return flow factor. Return flows returned in same month.
			-	return flow factor. Return flows returned in next month.
			0.	no return flow or flow returned out of basin
9	FILEID(I,5)	A8	BLANK	flow returned to next downstream control point
			AN	identifier of control point to return flow
10	GP	A8	BLANK	no group identifier
			AN	group identifier for water right.

Index I goes from 1 to NWRTS.

<u>WR Record</u> - Water Right Record - One Required - WRAP3

field	variable	format	value	description
1	CD	A2	WR	record identifier
2	WRID(I)	A6	AN	water right identifier, subscript "I" goes from 1 to NWRTS
3	CP	A8	AN	control point identifier
4	AMT	F8.0	0,+	annual permitted diversion
5	USE	A8	AN	use type identifier
6	WRNUM(I,7)	I8	+	priority number/date
7	WRNUM(I,5)	I8	BLANK,0,1	type 1 water right
			2	type 2 water right
			3	type 3 water right
			4	type 4 water right
			-1	hydropower right
8	RFAC	F8.0	+	return flow factor. Return flow returned in same month
			-	return flow factor. Return flow returned in next month.
			0	no return flow or flow returned out of basin
9	RCP	A8	BLANK	return flow returned to next downstream control point
			AN	identifier of control point to return flow
10	CP	A8	BLANK	no group identifier
			AN	group identifier for water right.

<u>WS Record</u> - Water Right Reservoir Storage - Optional - WRAP2

field	variable	format	value	description
1	GD	A2	WS	record identifier
2	FILEID(I,4)	A6	AN	reservoir identifier
3	FILE11(I,4)	F8.0	+	storage capacity of right
4	EVCFA	F8.0	+	first storage-area coefficient

			-	storage-area table entered for this reservoir
5	EVCFB	F8.0	+	second storage-area coefficient
6	EVCFC	F8.0	+	third storage-area coefficient

Fields 4, 5, and 6 are blank if reservoir is listed on a previous WS record.

WS Record - Water Right Reservoir Storage - Optional - WRAP3

field	variable	format	value	description
1	CD	A2	WS	record identifier
2	RES	A6	AN	reservoir identifier
3	WRSYS(I,3)	F8.0	+	storage capacity
4	EVCFA	F8.0	+	first storage-area coefficient (equation below)
			-	storage-area table entered on SV and SA records
5	EVCFB	F8.0	+	second storage-area coefficient
6	EVCFC	F8.0	+	third storage-area coefficient
7	WRSYS(I,1) or WRSYS(I,2)	F8.0	+	storage capacity at top of inactive pool (bottom of active pool) or storage capacity at bottom of power pool (hydropower right)
8	RESDAT(I,5)	F8.0	BLANK,0	reservoir is full to capacity (field 3) at beginning of simulation
			+	volume in storage at beginning of simulation
9	WRSYS(I,1)	F8.0	+	tailwater elevation for hydropower
10	WRSYS(I,4)	F8.0	+	water-to-wire efficiency for hydropower
11	SYSNUM(I,3)	I8	BLANK,0	downstream releases flow through hydropower turbines
			-	lakeside withdrawals do not flow through hydropower turbines

area = EVCFA * storage ** EVCFB + EVCFC

Fields 4, 5, and 6 can be left blank if the reservoir is listed on a previous WS record. Fields 9 and 10 are blank except for hydropower. Field 11 pertains to water rights involving releases which may affect some other hydropower right.

OR Record - Multiple-Reservoir Operating Rules-Optional-WRAP3

field	variable	format	value	description
1	CD	A2	OR	record identifier
2	CP	A6	AN	control point identifier for reservoir
3	WRSYS(I,2)	F8.0	+	storage capacity at top of zone 2 (bottom of zone 1)
4	WRSYS(I,5)	F8.0	+	zone 1 release priority factor
5	WRSYS(I,4)	F8.0	+	zone 2 release priority factor

6	SYSNUM(I,2)	I8	BLANK,0	releases constrained to gravity flow in river channels
			-	pump and pipeline conveyance as well as river flow

An OR record is required, in addition to a WS record, for each secondary reservoir associated with the water right (WR record). Field 2 can optionally be left blank if the control point identifier (CP) has been assigned to the reservoir identifier (RES) by a previous water right.

<u>WI Record</u> - Storage-Flow Data for Type 4 Right - Optional - WRAP3

field	variable	format	value	description
1	CD	A2	WI	record identifier
2	STOFLO(I,1)	F6.0	0	no reservoir releases
			-	no limit on reservoir releases
			+	limit on reservoir releases expressed as a decimal fraction of naturalized streamflow at the water right location
3	STOFLO(I,2)	F8.0	+	reservoir system storage content permitted
4	STOFLO(I,3)	F8.0	+	diversion amount
5	STOFLO(I,4)	F8.0	+	reservoir system storage content
6	STOFLO(I,5)	F8.0	+	permitted diversion amount
7	STOFLO(I,6)	F8.0	+	reservoir system storage content
8	STOFLO(I,7)	F8.0	+	permitted diversion amount
9	STOFLO(I,8)	F8.0	+	reservoir system storage content
10	STOFLO(I,9)	F8.0	+	permitted diversion amount

- Subsequent pairs are entered on second and third WI records. Field 2 is blank on second and third WI records. Maximum of 12 pairs may be entered. Subscript I represents index of type 4 right. A maximum of 50 type 4 rights may be entered.

<u>SV Record</u> - Storage-Area Table Volumes - Optional - WRAP2, WRAP3
- Two SV records must be entered for each table.

field	variable	format	value	description
1	CD	A2	SV	record identifier
2	RES	A6	AN	reservoir identifier if first SV record
	-		BLANK	if second SV record
3-8	TARA(1-6) TARA(7-12)	6F8.0	+	volumes on storage-area table

DESCRIPTION OF INPUT DATA RECORDS FOR WRAP2 AND WRAP3 (Continued)

SA Record - Storage-Area Table Areas - Optional - WRAP2, WRAP3
- Two SA records must be entered for each table immediately following the SV records.

field	variable	format	value	description
1	CD	A2	SA	record identifier
2	-	6X	BLANK	for both SA records
3-8	TARB(1-6) TARB(7-12)	6F8.0	+	areas on storage-area table

PV Record - Storage-Elevation Table Volumes - Optional - WRAP3
- Identical format as SV record

PE Record - Storage-Elevation Table Elevations - Optional - WRAP3
- Identical format as SA record

ED Record - End of Data for Basin Description - Required - WRAP2, WRAP3

field	variable	format	value	description
1	CD	A2	ED	record identifier

IN Record - Naturalized Streamflow at Control Points - Required - WRAP2, WRAP3

field	variable	format	value	description
1	CD	A2	IN	record identifier
2	CPIN(J)	A6	AN	control point identifier
3	PYR	I8	+	year of inflow
			-	year of inflows, but inflows equal inflows at control point identifier listed on field 4
4-9	INFLO(i,1-6)	6F8.0	0,+	inflows at control point for months 1-6 of year PYR
4	REPEAT	A6	AN	if PYR=negative, identifier of control point to set inflows equal to

- On second IN record for a control point, fields 2 and 3 are blank, and inflows for months 7-12 are in fields 4-9. A second IN record is not required if PYR=negative. IN records for all control points for a year must be entered before the EV records for that year.

EV Record - Net Evaporation Rate at Control Point - Required - WRAP2, WRAP3

- The format of EV records is identical to IN records except evaporation rates are entered instead of streamflows.
- IN records for a year for all control points are grouped together followed by all the EV records grouped together for the year.
- For a given year, the IN records for each control point can be in any order. Likewise, the control point order of the EV records is arbitrary.

APPENDIX B

DESCRIPTION OF INPUT DATA RECORDS FOR TABLES

DESCRIPTION OF INPUT DATA RECORDS FOR TABLES

The first four characters of each record consists of the record identifier. TITL records are placed at the beginning of the file. No more than five TITL records can be used. The ENDF record is the last record read. Any records placed after an ENDF record will not be read. With the exceptions of the TITL and ENDF records just mentioned, the records can be placed in any order. Any type of record can be used any number of times. All records are optional. There are no required records.

2SCP, 2SWR, 2SRE, 2NAT, 2UNA, 2DEP, 2SHT, 2STO, 2SRE, 2PER, 4SWR, and 4SGP records include the optional variable (IDEN(ID,I),I=1,NUM). Only eight values of IDEN can be entered on one record. Therefore, if NUM is greater than eight, the remaining values of IDEN are entered in fields 4-11 of subsequent records immediately following the first record. For NUM greater than 8, fields 2 and 3 of the second and subsequent records are not read. After (IDEN(ID,I), I=1,NUM) is entered one time, subsequent records can use the same IDEN identifiers, without reentering, by entering a negative value for NUM.

With the exception of TITL and COMM records, all data provided in a TABLES input file should be right-justified in each field.

<u>TITL Record</u> - Titles or Headings

From zero to five TITL records are entered as the first records of the input file. The alphanumeric information provided on the records is printed on the cover page and at the top of each table.

field	variable	format	value	description
1	CD	A4	TITL	record identifier
2	TITLE	A76	AN	title or heading

<u>COMM Record</u> - Comments

Any number of COMM records can be inserted anyplace in the input file to provide notes or comments. The COMM records are not read or used in any way by the program.

field	variable	format	value	description
1	CD	A4	COMM	record identifier
2	-	A76	AN	input file comment or note

<u>PAGE Record</u> - Title Page

field	variable	format	value	description
1	CD	A4	PAGE	prints title page

DESCRIPTION OF INPUT DATA RECORDS FOR TABLES (Continued)

ENDF Record - End of Input Data File

field	variable	format	value	description
1	CD	A4	ENDF	record identifier

1REC Record - Listing of Specified WRAP Input Records

field	variable	format	value	description
1	CD	A4	1REC	record identifier
2	KK	I4	0	list specified records
			nonzero	list all records except specified records
3	NUM	I4	+	number of record identifiers to follow
4-20	REC	17A4	AN	identifiers of specified WRAP input records
(REC(I),I=1,NUM)				

1SUM Record - Water Rights Summary

field	variable	format	value	description
1	CD	A4	1SUM	record identifier
2	KK	I4	1	summary by control point
			2	summary by type of use
			3	summary by water right type
			4	summary by water right group

1SRT Record - Listing of Sorted Water Rights

field	variable	format	value	description
1	CD	A4	1SRT	record identifier
2	KK	I4	0	listing of rights in priority order
			1	listing of rights by control point in priority order
			2	listing of rights by type-of-use in priority order
			3	listing of rights by water right type in priority order
			4	listing of rights by water right group in priority order

2SCP Record - Summary Table for a Control Point

field	variable	format	value	description
1	CD	A4	2SCP	record identifier
2	MNAN	I4	0	annual table
			1	monthly table
			2	both annual and monthly tables
3	NUM	I4	0	develop tables for all control points
			BLANK	if NUM is zero or negative

DESCRIPTION OF INPUT DATA RECORDS FOR TABLES (Continued)

			-	develop tables for NUM control points listed on a previous record
			+	number of control points to follow
4-11	IDEN	8A8	AN	identifiers of control points for which to develop tables (IDEN(ID,I),I=1,NUM)

<u>2SWR Record</u> - Summary Table for a Water Right

field	variable	format	value	description
1	CD	A4	2SWR	record identifier
2	MNAN	I4	0	annual table
			1	monthly table
			2	both annual and monthly tables
3	NUM	I4	0	develop tables for all water rights
			-	develop tables for NUM water rights listed on a previous record
			+	number of water rights to follow
4-11	IDEN	8A8	AN	identifiers of water rights for which to develop tables IDEN(ID,I),I=1,NUM)
			BLANK	if NUM is zero or negative

<u>2SRE Record</u> - Summary Table for a Reservoir

field	variable	format	value	description
1	CD	A4	2SRE	record identifier
2	MNAN	I4	0	annual table
			1	monthly table
			2	both annual and monthly tables
3	NUM	I4	0	develop tables for all reservoirs
			-	develop tables for NUM reservoirs listed on a previous record
			+	number of reservoirs to follow
4	IDEN	8A8	AN	identifiers of reservoirs for which to develop tables (IDEN(ID,I),I-1,NUM)
			BLANK	if NUM is zero or negative

<u>2SGP Record</u> - Summary Table for a Water Right Group

Same as 2SWR record except CD is 2SGP and IDEN denotes water right group identifiers. Water right groups must be listed explicitly. NUM cannot be zero for any water right group operation.

<u>2SBA Record</u> - Summary Table for River Basin (All Control Points)

field	variable	format	value	description
1	CD	A4	2SBA	record identifier

DESCRIPTION OF INPUT DATA RECORDS FOR TABLES (Continued)

2	MNAN	I4	0	annual table
			1	monthly table
			2	both annual and monthly tables

2REL Record - Reliability and Shortage Summary

field	variable	format	value	description
1	CD	A4	2REL	record identifier
2	ID	I4	0	table includes selected control points
			1	table includes selected water rights
			2	table includes selected hydropower reservoirs
			3	table includes selected water right groups
3	NUM	I4	0	include all control points (ID=0), water rights (ID=1), or reservoirs (ID=2) in table
			-	include NUM previously listed control points, water rights, reservoirs or water right groups in table
			+	number of control points, water rights, reservoirs or water right groups to follow
4-11	IDEN	8A8	AN	identifiers of control points (ID=0), water rights (ID=1), reservoirs (ID=2) or water right groups (ID=3) to include in table (IDEN(ID,I),I=1,NUM)
			BLANK	if NUM is zero or negative

2NAT Record - Naturalized Streamflow Table
2UNA Record - Unappropriated Streamflow Table
2DEP Record - Streamflow Depletion Table
2SHT Record - Shortage Table
2STO Record - Storage Table

field	variable	format	value	description
1	CD	A4	2NAT 2UNA 2DEP 2SHT 2STO	record identifier
2	ID	I4	0	develop tables for control points
			1	develop tables for water rights
			2	develop tables for reservoirs
			3	develop tables for water right groups
3	NUM	I4	0	develop table for all control points (ID=0), water rights (ID=1), or reservoirs (ID=2). NUM cannot be zero if ID=3.
			-	develop tables for NUM previously listed control points, water rights, or reservoirs
			+	number of control points, water rights, reservoirs, or water right groups to follow

4-11	IDEN	8A8	AN	identifiers of control points (ID=0), water rights (ID=1), reservoirs (ID=2), water right groups (ID=3) to include in table (IDEN(ID,I),I-1,NUM)
			BLANK	if NUM is zero or negative

<u>2PER Record</u> - Percent Storage and Storage-Duration Records

<u>First 2PER Record</u> (Fields 3-10 are continued on a second record for more than eight reservoirs. A maximum of 12 reservoirs can be included.)

field	variable	format	value	description
1	CD	A4	2PER	record identifier
2	NUM	I8	+	number of reservoirs
			-	reservoir identifiers previously entered
3-10	IDEN	8A8	AN	reservoir identifiers

<u>Subsequent 2PER Records</u> (four reservoirs per record)

field	variable	format	value	description
1	CD	A4	2PER	record identifier
2	-	8X	-	blank or comment
3	CAP	F8.0	+	inactive capacity in first reservoir
4	CAP	F8.0	+	total capacity in first reservoir
5	CAP	F8.0	+	inactive capacity in second reservoir
6	CAP	F8.0	+	total capacity in second reservoir
7	CAP	F8.0	+	inactive capacity in third reservoir
8	CAP	F8.0	+	total capacity in third reservoir
9	CAP	F8.0	+	inactive capacity in fourth reservoir
10	CAP	F8.0	+	total capacity in fourth reservoir

<u>First 3HEC Record</u>

field	variable	format	value	description
1	CD	A4	3HEC	record identifier
2	HEC	I4	3	HEC-3 format for IN and EV records
			5	HEC-5 format for IN and EV records
3	EV	I4	0	evaporation rate (EV) records are not included in output
			1	EV records are included
4	NEGYR	I4	0	"negative year" messages written
			+	"negative year" messages not written
5	IN	I4	1	unappropriated flows are output on IN records
			2	unappropriated flows plus streamflow depletions are output on IN records
			3	streamflow depletions are output on IN records
			4	naturalized streamflows are output on IN records

6	CPTS	I4	+	number of control points to include in output. A 3HEC record follows for each of CPTS control points
7	EVFAC	F8.4	BLANK	EVFAC=1.0
			+	factor by which evaporation rates are multiplied
8	INFAC	F8.4	BLANK	INFAC=1.0
			+	factor by which streamflows are multiplied

Second and Subsequent 3HEC Records for Each Control Point

field	variable	format	value	description
1	CD	A4	3HEC	record identifier
2	-	4X	AN	comment, not read by program
3	CPID	A8	AN	WRAP control point identifier
4	INCP	I4	+	control point identifier on HEC IN record
5	EVCT	I4	+	evaporation control point counter
6	EVID	I4	+	reservoir identifier on HEC EV record
7	NUM	I4	+	number of water rights
8-13	IDEN	6A8	AN	identifiers of water rights to include in streamflow depletion summation at this control point (IDEN(I,J),J=1,NUM)

3NAT Record - Naturalized Streamflows and Evaporation Rates in HEC Format

field	variable	format	value	description
1	CD	A4	3NAT	record identifier
2	HEC	I4	3	HEC-3 format for IN and EV records
			5	HEC-5 format for IN and EV records
3	EV	I4	0	evaporation rate (EV) records are not included in output
			1	EV records are included
4	NEGYR	I4	0	"negative year" messages written
5	EVFAC	F8.4	BLANK	EVFAC=1.0
			+	factor by which evaporation rates are multiplied
6	INFAC	F8.4	BLANK	INFAC=1.0

3UNA Record - Unappropriated Streamflows and Evaporation Rates in HEC Format

Same as 3NAT record except CD is 3UNA

3DEP Record - Streamflow Depletions and Evaporation Rates in HEC Format

Same as 3NAT record except CD is 3DEP

4SWR Record - System Reservoir Release Summary for a Water Right

field	variable	format	value	description
1	CD	A4	4SWR	record identifier
2	MNAN	I4	0	annual table
			1	monthly table

Job Type 4 Records

Job type 4 records result in tables being developed from the data contained in a system release/hydropower file. 4SWR or 4SGP records provide monthly or annual tabulations of system releases from all reservoirs associated with a water right or water right group. Each table can include up to 15 reservoirs. Releases tabulated for a primary reservoir include streamflow depletions made to meet the permitted diversion as well as water released or withdrawn from storage.

RUNNING THE MODEL

WRAP2, WRAP3, and TABLES are compiled and executed as separate individual programs. Both fortran source codes and compiled executable versions of the programs are available. The user can develop WRAP (WRAP2 or WRAP3) and TABLES input files following the instructions provided by Appendices A and B using any editor. The executable programs are run by typing the appropriate name, either WRAP2, WRAP3, or TABLES, assuming a microcomputer is being used with the Microsoft disk operating system (MS DOS) or equivalent. Execution of either of the programs begins with an interactive session which defines the pertinent input and output files.

The computer files involved in executing the programs are listed in Table 7. The terms "ROOT" and "EXT" refer to the root and extension of a file name (ROOT.EXT), which is named by the user. Some filenames have a root specified by the user, but the extension portion of the filename is specified by the program, such as OUT, ERR, ADJ, and SYS. The user-defined "ROOT" can also include a drive and directory path. Table 7 also indicates the unit numbers assigned to the files in the fortran open and format statements, which is useful information only when examining the fortran source codes.

The WRAP3 multiple-reservoir system release computations and hydroelectric power computations involve use of the temporary scratch files SCR10 and SCR11 to store intermediate results. The scratch files are automatically created; used to write, store, and retrieve computed data; and erased by the program. The user has the option of assigning a drive and directory path for the SCR10 and SCR11 files. If numerous water rights involving multiple-reservoir system operations are included in a simulation, the scratch files may be used quite extensively. A RAM (random-access memory) disk can be used to increase the computational speed.

The WRAP3 optional ROOT.SYS and ROOT.ADJ output files are created only if specified on the JD record of the input file.

A WRAP input filename (ROOT.DAT) has a user-defined root and the extension "DAT." The ROOT.DAT file may contain all the input records, including the title (T1, T2, T3) records through the hydrology (IN and EV) records (as defined in Appendix A). Since input files can be quite voluminous, WRAP3 provides the option of dividing the data into two files, ROOT.DAT and ROOT.HYD. The streamflow (IN) and evaporation (EV) records are stored in the hydrology file, ROOT.HYD, and all other records in the other file, ROOT.DAT. With this option, the ROOT.DAT file ends with the ED record.

Model execution begins with an interactive routine for defining the pertinent input and output files. The user responds to a series of prompts, involving either entering file names or yes/no responses. Either a Y, y, N, or n can be entered for a yes-or-no response or the default "yes" can be selected by simply pressing return. Only the root of the file names and, if desired, the drive and directory path, are entered for the WRAP programs, with the extensions being automatically assigned by the program. The complete file names, including extensions, are entered for TABLES.

Table 7
Computer Files

Fortran Program Files and Executable Program Files

WRAP2.FOR	WRAP2.EXE
WRAP3.FOR	WRAP3.EXE
TABLES.FOR	TABLES.EXE

WRAP Input Files

ROOT.DAT - WRAP2 or WRAP3 input file (unit-3)
ROOT.HYD - WRAP3 optional hydrology input file (unit-12)

WRAP Output Files

ROOT.OUT - WRAP2 or WRAP3 main output file (unit-4)
ROOT.ERR - WRAP2 or WRAP3 error file (unit-14)
ROOT.SYS - WRAP3 optional multireservoir system file (unit-13)
ROOT.ADJ - WRAP3 optional negative incremental flows (unit-9)
SCR10 & SCR11 - WRAP3 temporary scratch files used during the computations (units 10 & 11)

TABLES Input Files

ROOT.EXT - TABLES input file (unit-1)
ROOT.DAT - WRAP input file (unit-3)
ROOT.OUT - WRAP output file (unit-4)
ROOT.SYS - WRAP3 system file (unit-5)

TABLES Output File

ROOT.EXT - TABLES output file (unit-2)

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APPENDIX A

DESCRIPTION OF INPUT RECORDS FOR WRAP2 AND WRAP3

Table C-1
Example 1 - WRAP2 or WRAP3
Water Rights Listed in Priority Order

Water Right ID	Control Point ID	Reservoir ID	Return Flow Location	Permitted Diversion (ac-ft/yr)	Storage Capacity (ac-ft)
WR7	CP6	-		240	-
WR1	CP1	RES1	CP3	360	90
WR2	CP2	RES2	CP3	60	50
WR4	CP3	-	CP4	720	-
WR6	CP4	RES3	CP5	120	-
WR5	CP5	RES4	-	600	200
WR3	CP2	RES2	CP3	180	110
WR8	CP6	-	CP3	400	-
WR9	CP4	RES3	-	-	300

Table C-2
Example 2 - WRAP3
Water Rights Listed in Priority Order

Water Right ID	Water Right Type	Control Point ID	Return Flow Location	Permitted Diversion (ac-ft/yr)	Primary Reservoir ID	Primary Reservoir capacity (ac-ft)	Secondary Reservoir ID
WR7	1	CP6		240	-	-	-
WR1	1	CP1	CP3	360	RES1	90	-
WR2	1	CP2	CP3	60	RES2	50	-
WR4	2	CP3	-	720	-	-	RES1 RES2 RES3
WR6	1	CP4	-	120	-	-	RES3
WR5a	2	CP5	-	600	-	-	RES3 RES4
WR5b	1	CP5	-	-	RES4	200	-
WR3	1	CP2	CP3	180	RES2	110	-
WR8	4	CP6	CP3	400*	-	-	RES1 RES2 RES3
WR9	1**	CP4	-	-	RES3	300	-

* WR8 is a type 4 right with a variable permitted diversion of up to 400 ac-ft/yr depending on reservoir storage content.

** WR9 is a hydroelectric power right with a permitted firm energy of 24,000 kilowatt-hours.

Table C-3
Example 2 - WRAP3
Reservoir Storage Capacity

Reservoir ID	Primary or Secondary (P or S)	Water Right ID	Storage Capacity to Refill (ac-ft)	Inactive Pool Capacity (ac-ft)	Capacity at Top of Zone 1 (ac-ft)	Capacity at Top of Zone 2 (ac-ft)
RES1	P	WR1	90	10	-	-
	S	WR4	-	10	90	90
	S	WR8	-	10	90	90
RES2	P	WR2	50	25	-	-
	P	WR3	110	25	-	-
	S	WR4	-	25	110	80
	S	WR8	-	25	110	80
RES3	P	WR6		30	-	-
	P	WR9	300	30	-	-
	S	WR4	-	30	300	165
	S	WR5b	-	150	300	300
	S	WR8	-	30	300	165
RES4	S	WR5a	-	-	200	100
	P	WR5b	200	-	-	-

Output Data (JG and JR Records)

The WRAP output file consists of the output data records outlined in Table 5 on pages 45 and 46. Control point output records are written for all control points (blank field JD.11). Water rights and reservoir/hydropower records are outputted as specified by the JG and JR records. For the example, the output file includes records for all nine water rights, four reservoirs, and six control points. The -1 on the JR record calls for output for all four reservoirs. Normally, a -1 would also be specified on the JG record if all water rights are to be output. However, in order to illustrate the procedure for selecting records to output, the identifiers WR1, CP2, SYS, and WR7 are listed on the JG record. Thus, the water right output records will include: water right WR1 (field WR.2); all water rights associated with control point CP2 (field WR.3); all water rights with the group identifier SYS (field WR.10); and water right WR7 (field WR.2). This accounts for all nine water rights, but any number of water rights could be selected for output in a similar manner. (Note above that the notation WR.2 is used to refer to field 2 of the WR records in the input file.)

Monthly Use Factors (UC Records)

Two alternative sets of monthly water use distribution factors are provided. The set identified as 'CONST' will cause the monthly permitted diversion amounts to be computed as 1/12 of the annual amounts entered on field 4 of the water rights (WR) records. The set identified as 'IRRIG' results in monthly diversions of zero and 25% of the annual diversions in months September-April and May-August, respectively.

Monthly water use factors (UC records) are assigned to each water right by the water use type identifier in field 5 of the WR record, which is matched with field UC.2. This is the only purpose served by the water use type identifier in the WRAP computations. The identifiers, such as 'CONST', for constant, and 'IRRIG', for irrigation, are simply names created by the program user.

Control Point Data (CP Records)

Six control points are used to model the locational configuration of the two basins. For the most downstream control point in each basin, the label 'OUT' must be used in lieu of the identification of the next downstream control point.

Evaporation rates are entered in the EV records in units of feet/month, except for the rates at control point CP2, which are in inches. The CP record for CP2 includes a multiplier factor of 0.08333 foot/inch to convert the evaporation rates to feet/month. Streamflows are entered on the IN records in units of acre-feet/month, except for the flows at control point CP5, which are in 1,000 cubic meters/month. A conversion factor of 0.811 ac-ft/1,000 m^3 is provided on the CP record for control point CP5.

Storage-Area Table (WR, SV, and SA Records)

A storage volume versus water surface area relationship is required for each reservoir for use in the evaporation computations. The value of -1 in the fourth field of the first WS record for reservoir RES4 indicates that the storage-area relationship for RES4 is provided by a set of SV and SA records.

The inputted table consists of storages, in acre-feet, on the SV record and the corresponding areas, in acres, on the SA record.

The storage-area relationships for the other three reservoirs are provided by the alternative option involving coefficients entered on the first WS record for each reservoir (fields WS.4, WS.5, and WS.6). The model computes the area as:

area = (field WS.4) * storage ** (field WS.5) + (field WS.6)

For the example, the following simple linear relationship is assumed for all four reservoirs:

area in acres = 0.1 * storage in ac-ft

Inflow (IN) and Evaporation (EV) Records

Naturalized streamflows are provided for each month of the two-year simulation at each of the six control points on IN records. The streamflows are in acre-feet/month, except for flows at control point CP5 which are in units of thousand cubic meters/month. A conversion factor of 0.811 ac-ft/1,000 m^3 is provided on the CP record for control point CP5.

Reservoir evaporation rates are provided on EV records for each month of the simulation for the four control points at which reservoirs are located. The evaporation rates are in feet/month, except for the rates at control point CP2 which are in inches/month. The CP record for CP2 includes a conversion factor of 0.0833 foot/inch.

The IN records must precede the EV records for each year, but the order of the IN and EV records with respect to control points is arbitrary. Values for six months are provided on each record, thus two records are required for each year at each control point. Inflow or evaporation data repeated for multiple control points are identified on the IN or EV records by a negative year and the identifier of the control point from which the data are repeated. The evaporation rates entered for control point CP1 are also used for control points CP4 and CP5. The complete set of IN and EV records is preceded by a required ED record.

Records Which Vary Between Examples 1 and 2

Certain fields of the JD, WR, and WS records are different between the two examples. The WRAP3 OR, PV, and PE records used in example 2 cannot be read by WRAP2 and are not included in example 1.

Job Control (JD Record) - Examples 1 and 2

Examples 1 and 2 contain WRAP2 and WRAP3 JD records, respectively. The first four fields of the alternative JD records are identical and indicate that the two-year simulation period begins in 1988 and contains 12 periods (months) per year.

Fields 5, 6, and 7 of the WRAP2 JD record of example 1 indicate that the system includes six control points, nine water rights, and two water use types (sets of monthly use factors on UC records). This information is not included on a WRAP3 JD record because WRAP3 automatically counts the number of control points, water rights, and use types.

Fields 5-9 of a WRAP3 JD record contain information pertinent to optional features not available in WRAP2. The JD record of example 2 specifies a value of 1.0237 for the power factor (POWFCT), which is defined on pages 27 and 36. By leaving fields 6-9 blank, the following options are selected for example 2. Negative incremental inflow option 1, defined on page 30, will be used, and an adjustments file will not be written. End-of-period storages will be used in making multiple-reservoir release decisions, as discussed on page 26.

Water rights identifiers will be written to the output file instead of group identifiers (blank field WR.8). The JG record (field JG.5) includes the group identifier (field WR.10) 'SYS' to represent the group consisting of water rights WR4, WR5, WR6, WR8, and WR9. The water right identifiers will be written to the output file water rights records rather than the group identifier 'SYS'. The program TABLES uses the identifiers in developing certain tables from the WRAP output file. The group identifier does not affect the WRAP computations in any way.

A blank field JD.11 results in control point records being written to the output file. Field JD.11 allows records to be written for either all or none of the control points. Individual control points cannot be selected for output.

The example 1 input file can be run with either WRAP2 or WRAP3, with identical results. The JD record is the only record included in example 1 which varies between WRAP2 and WRAP3. A WRAP2 JD record is included in the file. Fields 5, 6, and 7 of the JD record would normally be blank for this example for WRAP3. However, for this particular data set, the WRAP2 data provided in fields 5, 6, and 7 of the JD record are simply not needed or used by WRAP3 and do not affect the model results.

Water Rights and Associated Reservoir Storage (WR and WS Records) - Example 1

Example 1 illustrates the format of a WRAP2 input file or a WRAP3 input file which is not complicated by the use of various optional WRAP3 features. As noted above, the input file reproduced in Supplement 1 can be run by either WRAP2 or WRAP3 even though the JD record is actually in WRAP2 format. All of the other records are in standard WRAP3, as well as WRAP2, format. By leaving various fields blank, certain optional WRAP3 features are not used.

The locational configuration of the system is delineated in Figure C1. The nine water rights are listed in priority order in Table C-1.

Water right WR7 (field WR.2) is the most senior right, with a priority number of 191805 (field WR.6) representing the date May 1918, which is smaller than the priority numbers of all the other rights. Thus, WR7 is the first right considered in the WRAP computations. WR7 is a run-of-river right with no reservoir storage (no WS record). WR7 has a permitted diversion of 240 ac-ft/yr (field WR.4) or 20 ac-ft/month (field WR.5 and UC records), which is withdrawn from the river at control point CP6 (field WR.3). Note that the notation WR.3 refers to field 3 of the WR record.

Water rights WR4 and WR8 (field WR.2) are also run-of-river rights with permitted diversion targets of 720 and 400 ac-ft/yr (field WR.4), respectively, located at control points CP3 and CP6 (field WR.3).

Water right WR4 represents a requirement to maintain a constant instream flow of 60 ac-ft/month or 720 ac-ft/yr at CP3. TAMUWRAP has no special features for instream flow requirements. An instream flow target is simply treated as a permitted diversion with 100% return flow. WR4 has a return flow factor of 1.0 (field WR.8) and return location of CP4 (blank field WR.9) which is the next downstream control point.

Water right WR1 allows refilling of reservoir RES1 to a capacity of 90 ac-ft as well as diverting 360 ac-ft/yr from RES1 inflows and storage. Water rights WR2 and WR3 refill storage in reservoir RES2 to total cumulative capacities of 50 and 110 ac-ft, respectively, as well as divert 60 and 180 ac-ft/yr, respectively. Thus, RES2 can be filled to a level of 50 ac-ft by the senior priority WR2, assuming sufficient streamflow is available, and then to a greater level of 110 ac-ft by the more junior WR3 if additional streamflow is still available. Both WR2 and WR3 diversions are met as long as RES2 is not empty. Storage versus area relationship coefficients must be entered in fields WS.4, WS.5, and WS.6 the first time a reservoir is listed but do not necessarily have to be repeated on subsequent WS records.

RES3 is associated with both WR6 and WR9. WR6 diverts 120 ac-ft/yr but does not refill storage. WR9 refills storage to a capacity of 300 ac-ft but has no permitted diversion. Thus, the permitted diversion and permitted storage capacity of RES3 have different priorities.

Reservoir RES4 located at control point CP5 is in a different river basin. Water right WR5 includes a permitted diversion of 600 ac-ft/yr from CP5 inflows and RES4 storage as well as the right to fill reservoir RES4 up to a capacity of 200 ac-ft as streamflow is available. The -1 in field WS.4 indicates that a storage versus area table is provided on a set of SV and SA records.

Return flow, if any, is specified in field WR.8 as a fraction of diversions. The location to which the diverted flow is returned is specified in field WR.9. If field WR.9 is blank, the flow is returned to the next downstream control point. A positive return flow factor in field WR.8 results in the return flow occurring in the same month as the diversion. If the return flow factor is preceded by a negative sign, the return flow occurs during the month following the diversion. Water rights WR1, WR2, and WR3 include same-month return flows of 20% of the diversion amount reentering the stream at the next downstream control point, which is CP3. WR5, WR7, and WR9 have no return flows. As previously discussed, WR4 has a 100% return flow to the next downstream control point, representing an instream flow requirement.

The pipelines (with pumps), shown by dashed lines in Figure C1, are associated with water rights WR6 and WR8 return flows. WR6 is an interbasin transfer of water. Water right WR6 returns 100% of its diversion from control point CP4 to CP5. WR8 at CP6 includes a next-month return flow of 50% of the diversion which reenters the river upstream at CP3.

Water Rights and Associated Reservoir Storage (WR, WS, OR, WI Records) - Example 2

The WRAP3 input file for example 2 is presented as Appendix C Supplement 2. The system is shown schematically in Figure C1. Water right and associated reservoir storage capacity data are tabulated in Tables C-2 and C-3. Example 2 was developed by adding multiple-reservoir system operation and hydroelectric power generation features to example 1. Water rights WR4, WR5, and WR8 have permitted diversions which can be met by releases from multiple reservoirs. WR9 is a hydroelectric power right. Inactive pools have also been defined for three of the reservoirs. Water rights WR1, WR2, and WR3 in example 2 are the same as for example 1 except for the addition of inactive storage pools. WR7 is the only water right which is identically the same in both examples.

Water Right WR1. - Water right WR1 (field WR.2) located at control point CP1 (field WR.3) has a permitted diversion of 360 ac-ft/yr (field WR.4), priority number of 192602 (field WR.6) representing February 1926, and same-month return flow of 20% (field WR.8) reentering the river at CP3 (blank field WR.9). The annual diversion amount is converted to monthly diversions using the monthly use factors (UC records) labeled 'CONST' (fields WR.5 and UC.2). WR1 is a type 1 (field WR.7 as defined on page 14) water right with RES1 (field WS.2) being its primary reservoir. Reservoir RES1 can be filled to a capacity of 90 ac-ft (field WS.3) and supply water for the WR1 diversion (field WR.4) until the storage level drops below the inactive pool capacity of 10 ac-ft (field WS.7). Withdrawals from the inactive pool (Figure 2 on page 19) can be made only by evaporation. The storage volume versus water surface area relationship coefficients (fields WS.4, WS.5, WS.6), used in the evaporation computations for RES1, must be entered with WR1 since this is the first time RES1 is listed but do not have to be repeated on subsequent RES1 WS records. (Remember that the shorthand notation WR.2 refers to field 2 of the WR record.)

Water Rights WR2 and WR3. - RES2 is the primary (and only) reservoir for both WR2 and WR3, which can refill it to total cumulative capacities of 50 and 110 ac-ft, respectively. WR2 and WR3 have permitted annual diversion amounts of 60 and 180 ac-ft/yr, respectively, which are met by CP2 inflows as long as yet unappropriated streamflow is available and then withdrawals from RES2 as long as the storage is above the inactive pool capacity of 25 ac-ft. WR3 is junior to WR2. Several other rights at other locations have priorities which fall between WR2 and WR3.

Water Right WR4. - WR4 is an instream flow right with three secondary reservoirs but no primary reservoir. Since TAMUWRAP has no special provisions for instream flows, the instream flow target is represented by a permitted diversion of 720 ac-ft/yr or 60 ac-ft/month and return flow factor of 1.0. Thus, 100% of the water diverted by WR4 at CP3 is returned during the same month at CP4, which has the same effect as maintaining a minimum flow of 60 ac-ft/month at CP3.

The WR4 permitted diversion is met first by available streamflow at CP3 and then, as necessary, by releases from reservoirs RES1 and RES2. RES3 is also a component of the WR4 three-reservoir system. Since the WR4 system includes only gravity flow conveyance in the river channels (blank field OR.6), RES3 at CP4 cannot contribute directly to the diversion at CP3 which is upstream. However, RES3 releases water as needed to meet the senior WR7 diversion at CP6 to prevent depletion, by WR7, of available streamflow at CP1, CP2, and CP3. WR4 is termed a type 2 right since (unlike a type 1 right) it does not refill reservoir storage and (like a type 1 but unlike a type 3 right) it makes releases from RES1 and RES2 only if sufficient streamflow is not available at CP3 for the diversion.

As discussed on pages 16-19, multiple-reservoir system operations are based on balancing the storage, as a percent of zone capacity, in each reservoir. A ranking factor for each reservoir is computed as follows.

$$\textit{rank factor} = (\textit{weighting factor}) \left[\frac{\textit{storage content in zone}}{\textit{storage capacity of zone}} \right]$$

The release is made from the reservoir with the greatest value for the rank factor. The reservoir zones are defined by Figure 2 on page 19. Zone 1 must be empty in all the reservoirs in the system in order for releases to be made from zone 2 of any of the reservoirs.

The weighting factors used in the above formula are input for each reservoir on fields 4 and 5 of the OR records. Weighting factors of either 1.0 or zero are used for the two zones of all reservoirs in the examples. Since only the relative magnitude between reservoirs matters, replacing the 1.0's with any positive constant number will yield the same result. Since the zeroes are assigned to zones with zero storage capacity, any other number will yield the same result.

For water right WR4, the RES2 cumulative storage capacities at the top of inactive zone, active zone 2, and active zone 1 are 25 ac-ft (field WS.7), 80 ac-ft (field OR.3), and 110 ac-ft (field WS.3). Thus, zones 1 and 2 have capacities of 30 ac-ft (110-80), and 55 ac-ft (80-25), respectively. RES1 has cumulative storage capacities at the top of inactive zone, active zone 2, and active zone 1 of 10, 90, and 90 ac-ft, respectively. Thus, since fields WS.3 and OR.2 both contain values of 90 ac-ft, RES2 zone 1 contains zero storage capacity. In order for a release to be made from RES1, the storage contents of RES2 must be below 80 ac-ft. The corresponding RES3 cumulative storage capacities are 30, 165, and 300 ac-ft. As previously discussed, RES3 is constrained to meeting downstream senior rights (WR7 at CP6) in lieu of passing inflows through CP1, CP2, and CP3 which would diminish the streamflow available for WR.4. The storage balancing criterion is applied subject to this constraint.

<u>Water Rights WR5a and WR5b</u>. Since multiple-reservoir release decisions are pertinent only to secondary reservoirs and storage capacity can be replenished only in a primary reservoir, WR5 is treated as two separate water rights WR5a and WR5b. Water right WR5a has a diversion of 50 ac-ft/month (600 ac-ft/yr) located at CP5 which is met by available streamflow at CP5 supplemented by releases from reservoirs RES3 and RES4. WR5b refills storage in RES4 from available streamflow. WR5b is assigned a priority junior to WR5a so that the RES4 storage capacity is refilled after, rather than before, the WR5a diversion and associated release decisions are completed.

With the exception of RES4, the reservoirs are full at the beginning of the simulation on 1 January 1988 (blank field WS.8). The storage content of RES4 is 100 ac-ft (field WS.8 for WR5b) when the simulation begins.

The WR5a diversion is supplied by water from the following sources in the order listed:

(1) streamflows at CP5 (inflows to RES4) until the streamflow is depleted,

(2) releases or withdrawals from RES4 until the reservoir is emptied to less than half its storage capacity, and

(3) releases and withdrawals from both RES3 and RES4 until RES3 is emptied to less than half its storage capacity and RES4 is empty.

When both RES3 and RES4 are supplying water, release decisions are based on balancing the percent full (or percent depleted) of specified zones consisting of the lower half of RES4 and the upper half of RES3. Shortages occur if the indicated streamflow and reservoir storage is insufficient to meet the permitted diversion. This WR5a multiple-reservoir operating policy is defined in the WRAP3 input file as follows. Active pool zone 1 (Figure 2 on page 19) in RES4 has a capacity of 100 ac-ft since the total cumulative capacities at the top of zone 1 is 200 ac-ft (field WS.3) and at the top of zone 2 (bottom of zone 10) is 100 ac-ft (field OR.3). The inactive pool has zero storage (field WS.7). Thus, the RES4 storage capacity is divided in half, with 100 ac-ft in the upper zone 1 and 100 ac-ft in the lower zone 2. For WR5a, reservoir RES3 has cumulative capacities at the top of inactive pool, active pool zone 2, and zone 1 of 150 ac-ft (field WS.7), 300 ac-ft (field OR.3), and 300 ac-ft (field WS.3). Thus, zone 1 in RES3 has zero capacity. RES4 must be half empty before water is taken from RES3. Likewise, water is not withdrawn from RES3 for WR5 if the storage content of RES3 falls below 150 ac-ft (field WS.7).

CP5 is located in a different river basin than the other control points. Water withdrawn from RES3 at CP4 is conveyed by pipeline (or some other means other than the gravity flow in river channels) to the WR5a diversion site at CP5. Consequently, a negative one is entered in field OR.6. Any negative integer in field OR.6 has the same effect of acting as a switch to allow a reservoir to release to a diversion with a control point location which is not downstream of the reservoir. Field WS.11 is also flagged with a negative integer indicating that the WR5a releases from RES3 do not pass through the hydroelectric power plant associated with water right WR9.

Water Right WR6. - WR6 diverts 120 ac-ft/yr at CP4 from available streamflow and RES4 storage. Since WR6 is not permitted to refill storage, a type 2 right (field WR.7) is specified.

Water Right WR7. - WR7 is a run-of-river right involving diversion of 240 ac-ft/yr at CP6.

Water Right WR8. - WR8 is a type 4 right (field WR.7) with the permitted diversion amount being a function (WI record) of the total storage content of reservoirs RES1, RES2, and RES3. The diversion is also a function of month of the year (field WR.5 and UC records). The permitted diversion is zero during the months from September through April (UC records). During the remaining four months, the permitted diversion varies from 100 ac-ft/month (field WI.6) when the three reservoirs are full with a total storage content of 500 ac-ft (field WI.5) to zero (field WI.4) when the storage content is 300 ac-ft (field WI.3).

In each month of the simulation, the diversion target is computed as the lesser of: (1) the diversion amount linearly interpolated from the storage-diversion table provided by the WI record, based on the total beginning-of-period storage in the system reservoirs; and (2) application of the monthly use factor (field WR.5 and UC records) to the annual diversion (field WR.4). All of the reservoirs with WS records for the water right are included in totaling system storage content.

After the model computes the type 4 permitted diversion amount, the multiple-reservoir release decision algorithm is the same as for type 1 and type 2 rights. The diversion is met from yet unappropriated streamflow at CP6 if sufficient streamflow is available. Otherwise, a release is made from either RES1, RES2, or RES3 depending on which reservoir has the highest ranking factor. The weighting factors and inactive, zone 1, and zone 2 storage capacities used to compute the comparative ranking factors for RES1, RES2, and RES3 for WR8 are identical to those previously defined for WR4.

WR8 returns 50% of the water diverted from CP6 by pipeline to CP3. The return flow reenters the river at CP3 during the next month after it is diverted at CP6 (fields WR.8 and WR.9).

Water Right WR9. - WR9 generates hydroelectric power and refills storage in RES3. With a POWFCT value of 1.0237 (field JD.5), the energy units are kilowatt-hours. The permitted firm energy is a constant 24,000 kw-hr (fields WR.4 and WR.5 and UC records). The cumulative total storage capacity and inactive pool (bottom of power pool) capacity are 300 ac-ft (field WS.3) and 30 ac-ft (field WS.7), respectively. The tailwater elevation is 5.0 feet (field WS.9) and the plant efficiency is 85% (field WS.10). All flows through control point CP4 can be diverted through the hydroelectric turbines except for the lakeside withdrawals from RES3 for WR5 (field WS.11 for RES3 for WR5). WR9 is a type 1 right with RES3 as the primary (and only) reservoir.

RES3 storage versus elevation data, used to compute the head term of the power equation, is provided on PV and PE records. The elevation is assumed to vary linearly from zero to 100 feet (fields PE.3 and PE.4) as storage varies from zero to 300 ac-ft (fields PV.3 and PV.4). A set of two PV and two PE records are required even if the second records are blank.

Example 1 Output

The WRAP main output file for example 1 is included in Appendix C Supplement 1, pages C-17 through C-29. A direct examination of this file can be a useful supplement to the TABLES output for tracking the computations. Reference to Table 5 on pages 45-46 is necessary since the WRAP output file contains no headings.

Program TABLES reads the WRAP input and output files and develops tables and data listings in various user-selected formats. Supplement 3, on pages C-37 through C-67, contains a TABLES input file and resulting output. Several different types of tables are included to illustrate the range of formats available. Comment records are inserted in the TABLES input file to indicate the types of tables being selected for output.

The TABLES output, reproduced as Supplement 3, begins with a title page printed in response to the PAGE record in the TABLES input file. The title or cover page reproduces a TAMUWRAP banner followed by the title records from the WRAP (T1, T2, T3 records) and TABLES (TITL records) input files. It also provides a count of the records in the TABLES input file and the file names for all pertinent files.

The type 1 records develop tabulations from the WRAP input file. The 1SRT record sorts the nine water rights into priority order and tabulates the basic data associated with each right. The water rights are summarized by control point by the 1SUM record. A similar water rights summary can be, but is not, developed by type of water use.

A reliability and shortage summary (2REL record) is printed next, which includes each of the six control points. A similar table can be, but is not, printed for selected water rights. This table provides a concise summary of the simulation results. The volume reliability is the volume of actual diversions during the 24-month simulation expressed as a percentage of the permitted diversion amount. For example, the permitted diversions for the two water rights at control point CP2 sum to 240 acre-feet/year, as recorded in the second column of the table. The shortages for the two CP2 water rights average 88.8 ac/ft-yr (third column). The corresponding volume reliability is:

$$((240.0 - 88.8 \text{ ac-ft/yr})/240.0 \text{ ac-ft/yr})\ 100\% = 63.02\%$$

as recorded in the fourth column of the table. The period reliability is the percentage of the 24 months during which all water right diversions at the control point are met without a shortage. For example, at control point CP2, shortages occur in 11 months (sixth column). Thus, the period reliability is 13/24 or 54.17% (fourth column). The shortage summary counts both the number of months and number of years during which the shortage volumes equal or exceed specified percentages of the permitted diversion amounts at each control point.

Monthly summary tables were specified for all control points (2SCP record) and all water rights (2SWR record). Similar tables can be, but are not, specified for reservoirs. If only one water right with only one reservoir is located at a control point, a majority of the columns in the 2SCP, 2SWR, and 2SRE records are identical. However, naturalized streamflows, return flows, and unappropriated streamflows are associated only with control points. Otherwise, a control point (2SCP record) summary table represents an aggregation of all the water rights located at the control point. Monthly and annual summary tables for the basin (2SBA record) are also included in the TABLES output, which represent an aggregation of data for all six control points in the simulation. The summary tables provide a water balance that can be used to track the simulation month by month.

Naturalized streamflow and unappropriated streamflow are tabulated by month for each control point by the 2NAT and 2UNA records. Yearly totals are also included in these tables. Tables in a similar format can be, but are not, developed for streamflow depletions and shortages for specified water rights and storage levels for specified reservoirs.

APPENDIX C SUPPLEMENTS

WRAP AND TABLES INPUT AND OUTPUT FILES

			2	both annual and monthly tables
3	NUM	I4	+	number of water rights to follow
4	FIRST	I4	0, BLANK	include the first 15 reservoirs associated with water right identifier in field 5 in the order listed on WS records in the WRAP3 input file
			+	include the FIRST reservoir associated with water right identifier in field 5 and the next 14 reservoirs in the order listed on WS records in the WRAP3 input file
5	IDEN	A8	AN	identifier of water right for which to develop system reservoir release tables
6	FIRST	I4	0, BLANK	include the first 15 reservoirs associated with water right identifier in field 7 in the order listed on WS records in the WRAP3 input file
			+	include the FIRST reservoir associated with water right identifier in field 7 in the order listed on WS records in the WRAP3 input file
7	IDEN	A8	AN	identifier of water right for which to develop system reservoir release tables
8	FIRST	I4	0, BLANK	same as above
			+	
9	IDEN	A4	AN	
10	FIRST	I4	0, BLANK	
11	IDEN	A4	AN	
12	FIRST	I4	0, BLANK	
13	IDEN	A4	AN	

<u>4SGP Record</u> - System Reservoir Release Summary Table for a Water Right Group

Same as a 4SWR record except CD is 4SGP, and IDEN denotes a water right group. For both 4SWR and 4SGP, NUM (field 3) must be a positive nonzero integer and the identifiers (fields 5, 7, 9, 11, 13) must be listed explicitly.

APPENDIX C

EXAMPLES

EXAMPLES

Two versions of a simplified fictitious stream/reservoir/rights system are provided as illustrative examples. Simple, rather than realistic, numbers are used to facilitate manual tracking of the model computations and to conveniently illustrate the format of the input and output data. Example 1 illustrates the basic capabilities contained in both WRAP2 and WRAP3. Example 2 is a modified version of example 1, which has been expanded to include WRAP3 system operation features. A complete set of WRAP3 and TABLES input and output files for both examples are available on computer diskette along with the programs. WRAP2 and TABLES input and output files for example 1 are reproduced here. These files are the same for either WRAP2 or WRAP3, with the minor exception noted later involving the JD record. The WRAP3 input file for example 2 is also included in this appendix. The following computer files are reproduced as Appendix C Supplements 1 through 3.

Supplement 1 - WRAP2 input and output files for example 1 (page C-17)
Supplement 2 - WRAP3 input file for example 2 (page C-31)
Supplement 3 - TABLES input and output files for example 1 (page C-37)

A schematic of the stream/reservoir/rights system modeled by the examples 1 and 2 data sets is presented in Figure C1. The water rights are listed in priority order, with information pertinent to examples 1 and 2, in Tables C-1 and C-2, respectively. The system consists of nine water rights involving four reservoirs and eight diversions located at six control points in two river basins. Two pipelines (with pumps) as well as river channels (gravity flow) connect the reservoirs and diversion sites. Example 2 uses the same basic configuration as the simpler example 1 but is expanded to include multiple-reservoir system operations and a hydroelectric power plant.

WRAP Input Data Files

Instructions for developing WRAP input files are outlined in Appendix A and illustrated here with the examples. The input files for examples 1 and 2 are reproduced in Appendix C supplements 1 and 2, respectively.

Data Organization and Documentation (T1, T2, T3, **, ED)

The input files begin with the required T1, T2, and T3 records, which provide title or header information for the output. The comment (**) records inserted throughout the files are not read by the computer model. The ED record is the same for all input files and simply separates the hydrology data (IN and EV records) from the other records.

Records Common to Examples 1 and 2

The JG, JR, UC, CP, SV, SA, IN, and EV records are identical for examples 1 and 2.

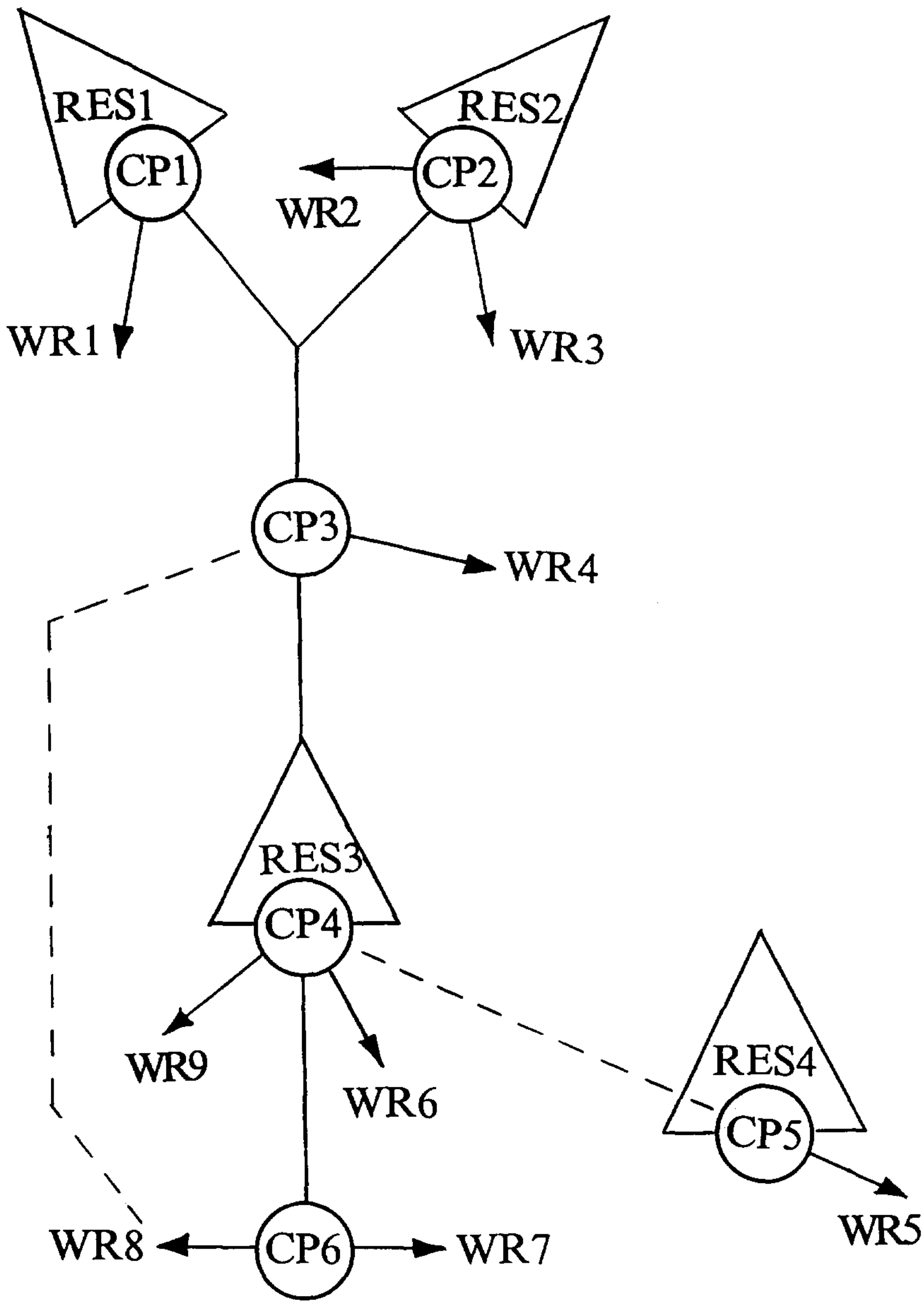

Figure C1. System Schematic

SUPPLEMENT 1

WRAP2 Input and Output Files for Example 1

```
T1  TAMUWRAP MODEL DESCRIPTION AND USERS MANUAL - APPENDIX C
T2  EXAMPLE 1 - A SIMPLIFIED DATA SET IS USED TO ILLUSTRATE THE BASIC
T3  MODEL CAPABILITIES WHICH ARE COMMON TO BOTH WRAP2 AND WRAP3.
**
**  WRAP2 OR WRAP3 INPUT FILE FOR EXAMPLE 1
**
**  JOB CONTROL RECORD
**
JD     2      12    1988       6       9       2
**
**  OUTPUT DATA FOR WATER RIGHTS (JG RECORD) AND RESERVOIRS (JR RECORD)
**
JG     4     WR1     CP2     SYS     WR7
JR    -1
**
**  MONTHLY USE FACTORS
**
UC CONST       1       1       1       1       1       1
UC             1       1       1       1       1       1
UC IRRIG       0       0       0       0    0.25    0.25
UC          0.25    0.25       0       0       0       0
**
**  CONTROL POINT RECORDS
**
CP   CP1     CP3
CP   CP2     CP3          0.08333
CP   CP3     CP4
CP   CP4     CP6
CP   CP5     OUT   0.811
CP   CP6     OUT
**
**  WATER RIGHTS AND ASSOCIATED RESERVOIR STORAGE
**
**  Water Right WR1  ------------------------------------------------
WR   WR1     CP1    360.   CONST  192602              .2
WS  RES1     90.     .1      1.      0.
**  Water Right WR2  ------------------------------------------------
WR   WR2     CP2     60.   IRRIG  193908              .2
WS  RES2     50.     .1      1.      0.
**  Water Right WR3  ------------------------------------------------
WR   WR3     CP2    180.   CONST  196506              .2
WS  RES2    110.     .1      1.      0.
**  Water Right WR4  ------------------------------------------------
WR   WR4     CP3    720.   CONST  195207             1.0             SYS
**  Water Right WR5  ------------------------------------------------
WR   WR5     CP5    600.   CONST  196212                             SYS
WS  RES4    200.     -1
**  Water Right WR6  ------------------------------------------------
WR   WR6     CP4    120.   CONST  195704             1.0     CP5     SYS
WS  RES3    300.     .1      1.      0.
**  Water Right WR7  ------------------------------------------------
WR   WR7     CP6    240.   CONST  191805
**  Water Right WR8  ------------------------------------------------
WR   WR8     CP6    400.   IRRIG  197412            -0.5     CP3     SYS
**  Water Right WR9  ------------------------------------------------
```

```
WR   WR9     CP4             CONST  197801                                      SYS
WS   RES3    300.
**
**   STORAGE VERSUS AREA TABLE FOR RESERVOIR RES4
**
SV   RES4          0.     200.
SV
SA                 0.      20.
SA
**
**   STREAMFLOW (IN) AND EVAPORATION RATE (EV) RECORDS
**
ED
IN    CP1     1988       60       60       60       60       60       60
IN                       10       10       10       10       10       10
IN    CP2     1988       20       20       20       20       20       20
IN                        0        0        0        0        0        0
IN    CP5     1988       74       74       74    12.33    12.33    12.33
IN                    12.33    12.33    12.33     92.5     92.5     92.5
IN    CP3     1988      120      120      120      100      100      100
IN                       30       30       30       30       30       30
IN    CP4     1988      120      120      120      120      120      120
IN                       40       40       40       40       40       40
IN    CP6     1988      150      150      150      180      180      180
IN                       50       50       50       50       50       50
EV    CP1     1988       .5       .5       .5       .5       .5       .5
EV                       .5       .5       .5       .5       .5       .5
EV    CP2     1988       6.       6.       6.       6.       6.       6.
EV                       6.       6.       6.       6.       6.       6.
EV    CP4    -1988      CP1
EV    CP5    -1988      CP1
IN    CP1     1989       60       60       60       60       60       60
IN                       10       10       10       10       10       10
IN    CP2     1989       20       20       20       20       20       20
IN                        0        0        0        0        0        0
IN    CP5     1989       74       74       74    12.33    12.33    12.33
IN                    12.33    12.33    12.33     92.5     92.5     92.5
IN    CP3     1989      120      120      120      100      100      100
IN                       30       30       30       30       30       30
IN    CP4     1989      120      120      120      120      120      120
IN                       40       40       40       40       40       40
IN    CP6     1989      150      150      150      180      180      180
IN                       50       50       50       50       50       50
EV    CP1     1989       .5       .5       .5       .5       .5       .5
EV                       .5       .5       .5       .5       .5       .5
EV    CP2     1989       6.       6.       6.       6.       6.       6.
EV                       6.       6.       6.       6.       6.       6.
EV    CP4    -1989      CP1
EV    CP5    -1989      CP1
**
**   END OF FILE
```

PROGRAM "WRAP3" (MARCH 1993 VERSION) OUTPUT FILE
TAMUWRAP MODEL DESCRIPTION AND USERS MANUAL - APPENDIX C
EXAMPLE 1 - A SIMPLIFIED DATA SET IS USED TO ILLUSTRATE THE BASIC
MODEL CAPABILITIES WHICH ARE COMMON TO BOTH WRAP2 AND WRAP3.

1988 2 12 6 9 4

WR7	0.0	20.0	0.0	0.0	20.0	150.0	0.0	1988	1
WR1	0.0	30.0	4.5	90.0	34.5	60.0	0.0	1988	1
WR2	0.0	0.0	2.5	50.0	2.5	20.0	0.0	1988	1
WR4	0.0	60.0	0.0	0.0	60.0	89.0	0.0	1988	1
WR6	0.0	10.0	15.0	300.0	25.0	89.0	0.0	1988	1
WR5	0.0	50.0	10.0	200.0	60.0	70.0	0.0	1988	1
WR3	0.0	15.0	5.5	109.5	17.5	17.5	0.0	1988	1
WR8	0.0	0.0	0.0	0.0	0.0	59.5	0.0	1988	1
WR9	0.0	0.0	15.0	300.0	0.0	49.5	0.0	1988	1
CP1	0.0	30.0	4.5	90.0	34.5	14.5	0.0		60.0
CP2	0.0	15.0	5.5	109.5	20.0	0.0	0.0		20.0
CP3	0.0	60.0	0.0	0.0	60.0	14.5	9.0		120.0
CP4	0.0	10.0	15.0	300.0	25.0	49.5	60.0		120.0
CP5	0.0	50.0	10.0	200.0	60.0	10.0	10.0		60.0
CP6	0.0	20.0	0.0	0.0	20.0	59.5	0.0		150.0
RES1	0.0	0.0	4.5	90.0	34.5	0.0	30.0		0.0
RES2	0.0	0.0	5.5	109.5	20.0	0.0	15.0		0.0
RES4	0.0	0.0	10.0	200.0	60.0	0.0	50.0		0.0
RES3	0.0	0.0	15.0	300.0	25.0	0.0	10.0		0.0
WR7	0.0	20.0	0.0	0.0	20.0	150.0	0.0	1988	2
WR1	0.0	30.0	4.5	90.0	34.5	60.0	0.0	1988	2
WR2	0.0	0.0	2.5	50.0	2.5	20.0	0.0	1988	2
WR4	0.0	60.0	0.0	0.0	60.0	89.0	0.0	1988	2
WR6	0.0	10.0	15.0	300.0	25.0	89.0	0.0	1988	2
WR5	0.0	50.0	10.0	200.0	60.0	70.0	0.0	1988	2
WR3	0.0	15.0	5.5	109.0	17.5	17.5	0.0	1988	2
WR8	0.0	0.0	0.0	0.0	0.0	59.5	0.0	1988	2
WR9	0.0	0.0	15.0	300.0	0.0	49.5	0.0	1988	2
CP1	0.0	30.0	4.5	90.0	34.5	14.5	0.0		60.0
CP2	0.0	15.0	5.5	109.0	20.0	0.0	0.0		20.0
CP3	0.0	60.0	0.0	0.0	60.0	14.5	9.0		120.0
CP4	0.0	10.0	15.0	300.0	25.0	49.5	60.0		120.0
CP5	0.0	50.0	10.0	200.0	60.0	10.0	10.0		60.0
CP6	0.0	20.0	0.0	0.0	20.0	59.5	0.0		150.0
RES1	0.0	0.0	4.5	90.0	34.5	0.0	30.0		0.0
RES2	0.0	0.0	5.5	109.0	20.0	0.0	15.0		0.0
RES4	0.0	0.0	10.0	200.0	60.0	0.0	50.0		0.0
RES3	0.0	0.0	15.0	300.0	25.0	0.0	10.0		0.0
WR7	0.0	20.0	0.0	0.0	20.0	150.0	0.0	1988	3
WR1	0.0	30.0	4.5	90.0	34.5	60.0	0.0	1988	3
WR2	0.0	0.0	2.5	50.0	2.5	20.0	0.0	1988	3
WR4	0.0	60.0	0.0	0.0	60.0	89.0	0.0	1988	3
WR6	0.0	10.0	15.0	300.0	25.0	89.0	0.0	1988	3
WR5	0.0	50.0	10.0	200.0	60.0	70.0	0.0	1988	3
WR3	0.0	15.0	5.4	108.6	17.5	17.5	0.0	1988	3
WR8	0.0	0.0	0.0	0.0	0.0	59.5	0.0	1988	3
WR9	0.0	0.0	15.0	300.0	0.0	49.5	0.0	1988	3

CP1	0.0	30.0	4.5	90.0	34.5	14.5	0.0		60.0
CP2	0.0	15.0	5.4	108.6	20.0	0.0	0.0		20.0
CP3	0.0	60.0	0.0	0.0	60.0	14.5	9.0		120.0
CP4	0.0	10.0	15.0	300.0	25.0	49.5	60.0		120.0
CP5	0.0	50.0	10.0	200.0	60.0	10.0	10.0		60.0
CP6	0.0	20.0	0.0	0.0	20.0	59.5	0.0		150.0
RES1	0.0	0.0	4.5	90.0	34.5	0.0	30.0		0.0
RES2	0.0	0.0	5.4	108.6	20.0	0.0	15.0		0.0
RES4	0.0	0.0	10.0	200.0	60.0	0.0	50.0		0.0
RES3	0.0	0.0	15.0	300.0	25.0	0.0	10.0		0.0
WR7	0.0	20.0	0.0	0.0	20.0	180.0	0.0	1988	4
WR1	0.0	30.0	4.5	90.0	34.5	60.0	0.0	1988	4
WR2	0.0	0.0	2.5	50.0	2.5	20.0	0.0	1988	4
WR4	0.0	60.0	0.0	0.0	60.0	69.0	0.0	1988	4
WR6	0.0	10.0	15.0	300.0	25.0	89.0	0.0	1988	4
WR5	0.0	50.0	9.0	161.0	20.0	20.0	0.0	1988	4
WR3	0.0	15.0	5.2	99.9	9.0	9.0	0.0	1988	4
WR8	0.0	0.0	0.0	0.0	0.0	98.0	0.0	1988	4
WR9	0.0	0.0	15.0	300.0	0.0	58.0	0.0	1988	4
CP1	0.0	30.0	4.5	90.0	34.5	3.0	0.0		60.0
CP2	0.0	15.0	5.2	99.9	11.5	3.0	0.0		20.0
CP3	0.0	60.0	0.0	0.0	60.0	3.0	9.0		100.0
CP4	0.0	10.0	15.0	300.0	25.0	58.0	60.0		120.0
CP5	0.0	50.0	9.0	161.0	20.0	0.0	10.0		10.0
CP6	0.0	20.0	0.0	0.0	20.0	98.0	0.0		180.0
RES1	0.0	0.0	4.5	90.0	34.5	0.0	30.0		0.0
RES2	0.0	0.0	5.2	99.9	11.5	0.0	15.0		0.0
RES4	0.0	0.0	9.0	161.0	20.0	0.0	50.0		0.0
RES3	0.0	0.0	15.0	300.0	25.0	0.0	10.0		0.0
WR7	0.0	20.0	0.0	0.0	20.0	180.0	0.0	1988	5
WR1	0.0	30.0	4.5	90.0	34.5	60.0	0.0	1988	5
WR2	0.0	15.0	2.5	50.0	17.5	20.0	0.0	1988	5
WR4	3.0	60.0	0.0	0.0	57.0	57.0	0.0	1988	5
WR6	0.0	10.0	15.0	300.0	25.0	77.0	0.0	1988	5
WR5	0.0	50.0	7.1	123.9	20.0	20.0	0.0	1988	5
WR3	0.0	15.0	4.6	82.8	0.0	0.0	0.0	1988	5
WR8	5.0	100.0	0.0	0.0	95.0	95.0	0.0	1988	5
WR9	0.0	0.0	15.0	300.0	0.0	0.0	0.0	1988	5
CP1	0.0	30.0	4.5	90.0	34.5	0.0	0.0		60.0
CP2	0.0	30.0	4.6	82.8	17.5	0.0	0.0		20.0
CP3	3.0	60.0	0.0	0.0	57.0	0.0	12.0		100.0
CP4	0.0	10.0	15.0	300.0	25.0	0.0	57.0		120.0
CP5	0.0	50.0	7.1	123.9	20.0	0.0	10.0		10.0
CP6	5.0	120.0	0.0	0.0	115.0	0.0	0.0		180.0
RES1	0.0	0.0	4.5	90.0	34.5	0.0	30.0		0.0
RES2	0.0	0.0	4.6	82.8	17.5	0.0	30.0		0.0
RES4	0.0	0.0	7.1	123.9	20.0	0.0	50.0		0.0
RES3	0.0	0.0	15.0	300.0	25.0	0.0	10.0		0.0
WR7	0.0	20.0	0.0	0.0	20.0	227.5	0.0	1988	6
WR1	0.0	30.0	4.5	90.0	34.5	60.0	0.0	1988	6
WR2	0.0	15.0	2.5	50.0	17.5	20.0	0.0	1988	6
WR4	0.0	60.0	0.0	0.0	60.0	104.5	0.0	1988	6

WR6	0.0	10.0	15.0	300.0	25.0	124.5	0.0	1988	6
WR5	0.0	50.0	5.3	88.5	20.0	20.0	0.0	1988	6
WR3	0.0	15.0	3.8	69.0	2.5	2.5	0.0	1988	6
WR8	0.0	100.0	0.0	0.0	100.0	140.0	0.0	1988	6
WR9	0.0	0.0	15.0	300.0	0.0	40.0	0.0	1988	6
CP1	0.0	30.0	4.5	90.0	34.5	25.5	0.0		60.0
CP2	0.0	30.0	3.8	69.0	20.0	0.0	0.0		20.0
CP3	0.0	60.0	0.0	0.0	60.0	40.0	59.5		100.0
CP4	0.0	10.0	15.0	300.0	25.0	40.0	60.0		120.0
CP5	0.0	50.0	5.3	88.5	20.0	0.0	10.0		10.0
CP6	0.0	120.0	0.0	0.0	120.0	40.0	0.0		180.0
RES1	0.0	0.0	4.5	90.0	34.5	0.0	30.0		0.0
RES2	0.0	0.0	3.8	69.0	20.0	0.0	30.0		0.0
RES4	0.0	0.0	5.3	88.5	20.0	0.0	50.0		0.0
RES3	0.0	0.0	15.0	300.0	25.0	0.0	10.0		0.0
WR7	0.0	20.0	0.0	0.0	20.0	100.0	0.0	1988	7
WR1	0.0	30.0	3.9	66.1	10.0	10.0	0.0	1988	7
WR2	0.0	15.0	2.1	32.9	0.0	0.0	0.0	1988	7
WR4	0.0	60.0	0.0	0.0	60.0	79.0	0.0	1988	7
WR6	0.0	10.0	15.0	300.0	25.0	79.0	0.0	1988	7
WR5	0.0	50.0	3.6	55.0	20.0	20.0	0.0	1988	7
WR3	0.0	15.0	2.6	36.4	0.0	0.0	0.0	1988	7
WR8	43.0	100.0	0.0	0.0	57.0	57.0	0.0	1988	7
WR9	0.0	0.0	15.0	300.0	0.0	0.0	0.0	1988	7
CP1	0.0	30.0	3.9	66.1	10.0	0.0	0.0		10.0
CP2	0.0	30.0	2.6	36.4	0.0	0.0	0.0		0.0
CP3	0.0	60.0	0.0	0.0	60.0	0.0	62.0		30.0
CP4	0.0	10.0	15.0	300.0	25.0	0.0	60.0		40.0
CP5	0.0	50.0	3.6	55.0	20.0	0.0	10.0		10.0
CP6	43.0	120.0	0.0	0.0	77.0	0.0	0.0		50.0
RES1	0.0	0.0	3.9	66.1	10.0	0.0	30.0		0.0
RES2	0.0	0.0	2.6	36.4	0.0	0.0	30.0		0.0
RES4	0.0	0.0	3.6	55.0	20.0	0.0	50.0		0.0
RES3	0.0	0.0	15.0	300.0	25.0	0.0	10.0		0.0
WR7	0.0	20.0	0.0	0.0	20.0	78.5	0.0	1988	8
WR1	0.0	30.0	2.7	43.4	10.0	10.0	0.0	1988	8
WR2	0.0	15.0	1.4	20.0	0.0	0.0	0.0	1988	8
WR4	2.5	60.0	0.0	0.0	57.5	57.5	0.0	1988	8
WR6	0.0	10.0	15.0	300.0	25.0	57.5	0.0	1988	8
WR5	0.0	50.0	1.9	23.0	20.0	20.0	0.0	1988	8
WR3	0.0	15.0	1.0	5.4	0.0	0.0	0.0	1988	8
WR8	64.5	100.0	0.0	0.0	35.5	35.5	0.0	1988	8
WR9	0.0	0.0	15.0	300.0	0.0	0.0	0.0	1988	8
CP1	0.0	30.0	2.7	43.4	10.0	0.0	0.0		10.0
CP2	0.0	30.0	1.0	5.4	0.0	0.0	0.0		0.0
CP3	2.5	60.0	0.0	0.0	57.5	0.0	40.5		30.0
CP4	0.0	10.0	15.0	300.0	25.0	0.0	57.5		40.0
CP5	0.0	50.0	1.9	23.0	20.0	0.0	10.0		10.0
CP6	64.5	120.0	0.0	0.0	55.5	0.0	0.0		50.0
RES1	0.0	0.0	2.7	43.4	10.0	0.0	30.0		0.0
RES2	0.0	0.0	1.0	5.4	0.0	0.0	30.0		0.0
RES4	0.0	0.0	1.9	23.0	20.0	0.0	50.0		0.0

RES3	0.0	0.0	15.0	300.0	25.0	0.0	10.0		0.0
WR7	0.0	20.0	0.0	0.0	20.0	67.8	0.0	1988	9
WR1	0.0	30.0	1.6	21.7	10.0	10.0	0.0	1988	9
WR2	0.0	0.0	0.3	5.1	0.0	0.0	0.0	1988	9
WR4	16.3	60.0	0.0	0.0	43.8	43.8	0.0	1988	9
WR6	0.0	10.0	15.0	300.0	25.0	43.8	0.0	1988	9
WR5	7.6	50.0	0.6	0.0	20.0	20.0	0.0	1988	9
WR3	9.8	15.0	0.1	0.0	0.0	0.0	0.0	1988	9
WR8	0.0	0.0	0.0	0.0	0.0	19.8	0.0	1988	9
WR9	0.0	0.0	15.0	300.0	0.0	19.8	0.0	1988	9
CP1	0.0	30.0	1.6	21.7	10.0	0.0	0.0		10.0
CP2	9.8	15.0	0.1	0.0	0.0	0.0	0.0		0.0
CP3	16.3	60.0	0.0	0.0	43.8	1.0	24.8		30.0
CP4	0.0	10.0	15.0	300.0	25.0	19.8	43.8		40.0
CP5	7.6	50.0	0.6	0.0	20.0	0.0	10.0		10.0
CP6	0.0	20.0	0.0	0.0	20.0	19.8	0.0		50.0
RES1	0.0	0.0	1.6	21.7	10.0	0.0	30.0		0.0
RES2	0.0	0.0	0.1	0.0	0.0	0.0	5.2		0.0
RES4	0.0	0.0	0.6	0.0	20.0	0.0	42.4		0.0
RES3	0.0	0.0	15.0	300.0	25.0	0.0	10.0		0.0
WR7	0.0	20.0	0.0	0.0	20.0	50.0	0.0	1988	10
WR1	0.0	30.0	0.6	1.2	10.0	10.0	0.0	1988	10
WR2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1988	10
WR4	34.0	60.0	0.0	0.0	26.0	26.0	0.0	1988	10
WR6	0.0	10.0	15.0	300.0	25.0	26.0	0.0	1988	10
WR5	0.0	50.0	0.9	34.2	85.0	85.0	0.0	1988	10
WR3	15.0	15.0	0.0	0.0	0.0	0.0	0.0	1988	10
WR8	0.0	0.0	0.0	0.0	0.0	1.0	0.0	1988	10
WR9	0.0	0.0	15.0	300.0	0.0	1.0	0.0	1988	10
CP1	0.0	30.0	0.6	1.2	10.0	0.0	0.0		10.0
CP2	15.0	15.0	0.0	0.0	0.0	0.0	0.0		0.0
CP3	34.0	60.0	0.0	0.0	26.0	0.0	6.0		30.0
CP4	0.0	10.0	15.0	300.0	25.0	1.0	26.0		40.0
CP5	0.0	50.0	0.9	34.2	85.0	0.0	10.0		75.0
CP6	0.0	20.0	0.0	0.0	20.0	1.0	0.0		50.0
RES1	0.0	0.0	0.6	1.2	10.0	0.0	30.0		0.0
RES2	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0
RES4	0.0	0.0	0.9	34.2	85.0	0.0	50.0		0.0
RES3	0.0	0.0	15.0	300.0	25.0	0.0	10.0		0.0
WR7	0.0	20.0	0.0	0.0	20.0	50.0	0.0	1988	11
WR1	18.9	30.0	0.0	0.0	10.0	10.0	0.0	1988	11
WR2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1988	11
WR4	37.8	60.0	0.0	0.0	22.2	22.2	0.0	1988	11
WR6	0.0	10.0	14.9	297.3	22.2	22.2	0.0	1988	11
WR5	0.0	50.0	2.5	66.7	85.0	85.0	0.0	1988	11
WR3	15.0	15.0	0.0	0.0	0.0	0.0	0.0	1988	11
WR8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1988	11
WR9	0.0	0.0	14.9	297.3	0.0	0.0	0.0	1988	11
CP1	18.9	30.0	0.0	0.0	10.0	0.0	0.0		10.0
CP2	15.0	15.0	0.0	0.0	0.0	0.0	0.0		0.0
CP3	37.8	60.0	0.0	0.0	22.2	0.0	2.2		30.0
CP4	0.0	10.0	14.9	297.3	22.2	0.0	22.2		40.0

CP5	0.0	50.0	2.5	66.7	85.0	0.0	10.0		75.0
CP6	0.0	20.0	0.0	0.0	20.0	0.0	0.0		50.0
RES1	0.0	0.0	0.0	0.0	10.0	0.0	11.1		0.0
RES2	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0
RES4	0.0	0.0	2.5	66.7	85.0	0.0	50.0		0.0
RES3	0.0	0.0	14.9	297.3	22.2	0.0	10.0		0.0
WR7	0.0	20.0	0.0	0.0	20.0	50.0	0.0	1988	12
WR1	20.0	30.0	0.0	0.0	10.0	10.0	0.0	1988	12
WR2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1988	12
WR4	38.0	60.0	0.0	0.0	22.0	22.0	0.0	1988	12
WR6	0.0	10.0	14.8	294.5	22.0	22.0	0.0	1988	12
WR5	0.0	50.0	4.1	97.6	85.0	85.0	0.0	1988	12
WR3	15.0	15.0	0.0	0.0	0.0	0.0	0.0	1988	12
WR8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1988	12
WR9	0.0	0.0	14.8	294.5	0.0	0.0	0.0	1988	12
CP1	20.0	30.0	0.0	0.0	10.0	0.0	0.0		10.0
CP2	15.0	15.0	0.0	0.0	0.0	0.0	0.0		0.0
CP3	38.0	60.0	0.0	0.0	22.0	0.0	2.0		30.0
CP4	0.0	10.0	14.8	294.5	22.0	0.0	22.0		40.0
CP5	0.0	50.0	4.1	97.6	85.0	0.0	10.0		75.0
CP6	0.0	20.0	0.0	0.0	20.0	0.0	0.0		50.0
RES1	0.0	0.0	0.0	0.0	10.0	0.0	10.0		0.0
RES2	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0
RES4	0.0	0.0	4.1	97.6	85.0	0.0	50.0		0.0
RES3	0.0	0.0	14.8	294.5	22.0	0.0	10.0		0.0
WR7	0.0	20.0	0.0	0.0	20.0	150.0	0.0	1989	1
WR1	0.0	30.0	0.7	29.3	60.0	60.0	0.0	1989	1
WR2	0.0	0.0	0.5	19.5	20.0	20.0	0.0	1989	1
WR4	14.0	60.0	0.0	0.0	46.0	46.0	0.0	1989	1
WR6	0.0	10.0	14.9	300.0	30.4	46.0	0.0	1989	1
WR5	0.0	50.0	5.2	112.3	70.0	70.0	0.0	1989	1
WR3	0.0	15.0	0.1	4.9	0.0	0.0	0.0	1989	1
WR8	0.0	0.0	0.0	0.0	0.0	28.6	0.0	1989	1
WR9	0.0	0.0	14.9	300.0	0.0	18.6	0.0	1989	1
CP1	0.0	30.0	0.7	29.3	60.0	0.0	0.0		60.0
CP2	0.0	15.0	0.1	4.9	20.0	0.0	0.0		20.0
CP3	14.0	60.0	0.0	0.0	46.0	3.0	9.0		120.0
CP4	0.0	10.0	14.9	300.0	30.4	18.6	46.0		120.0
CP5	0.0	50.0	5.2	112.3	70.0	0.0	10.0		60.0
CP6	0.0	20.0	0.0	0.0	20.0	28.6	0.0		150.0
RES1	0.0	0.0	0.7	29.3	60.0	0.0	30.0		0.0
RES2	0.0	0.0	0.1	4.9	20.0	0.0	15.0		0.0
RES4	0.0	0.0	5.2	112.3	70.0	0.0	50.0		0.0
RES3	0.0	0.0	14.9	300.0	30.4	0.0	10.0		0.0
WR7	0.0	20.0	0.0	0.0	20.0	150.0	0.0	1989	2
WR1	0.0	30.0	2.2	57.1	60.0	60.0	0.0	1989	2
WR2	0.0	0.0	0.7	24.2	20.0	20.0	0.0	1989	2
WR4	14.0	60.0	0.0	0.0	46.0	46.0	0.0	1989	2
WR6	0.0	10.0	15.0	300.0	25.0	46.0	0.0	1989	2
WR5	0.0	50.0	6.0	126.4	70.0	70.0	0.0	1989	2
WR3	0.0	15.0	0.4	9.5	0.0	0.0	0.0	1989	2
WR8	0.0	0.0	0.0	0.0	0.0	34.0	0.0	1989	2

WR9	0.0	0.0	15.0	300.0	0.0	24.0	0.0	1989	2
CP1	0.0	30.0	2.2	57.1	60.0	0.0	0.0		60.0
CP2	0.0	15.0	0.4	9.5	20.0	0.0	0.0		20.0
CP3	14.0	60.0	0.0	0.0	46.0	3.0	9.0		120.0
CP4	0.0	10.0	15.0	300.0	25.0	24.0	46.0		120.0
CP5	0.0	50.0	6.0	126.4	70.0	0.0	10.0		60.0
CP6	0.0	20.0	0.0	0.0	20.0	34.0	0.0		150.0
RES1	0.0	0.0	2.2	57.1	60.0	0.0	30.0		0.0
RES2	0.0	0.0	0.4	9.5	20.0	0.0	15.0		0.0
RES4	0.0	0.0	6.0	126.4	70.0	0.0	50.0		0.0
RES3	0.0	0.0	15.0	300.0	25.0	0.0	10.0		0.0
WR7	0.0	20.0	0.0	0.0	20.0	150.0	0.0	1989	3
WR1	0.0	30.0	3.5	83.6	60.0	60.0	0.0	1989	3
WR2	0.0	0.0	1.0	28.6	20.0	20.0	0.0	1989	3
WR4	14.0	60.0	0.0	0.0	46.0	46.0	0.0	1989	3
WR6	0.0	10.0	15.0	300.0	25.0	46.0	0.0	1989	3
WR5	0.0	50.0	6.7	139.7	70.0	70.0	0.0	1989	3
WR3	0.0	15.0	0.6	13.9	0.0	0.0	0.0	1989	3
WR8	0.0	0.0	0.0	0.0	0.0	34.0	0.0	1989	3
WR9	0.0	0.0	15.0	300.0	0.0	24.0	0.0	1989	3
CP1	0.0	30.0	3.5	83.6	60.0	0.0	0.0		60.0
CP2	0.0	15.0	0.6	13.9	20.0	0.0	0.0		20.0
CP3	14.0	60.0	0.0	0.0	46.0	3.0	9.0		120.0
CP4	0.0	10.0	15.0	300.0	25.0	24.0	46.0		120.0
CP5	0.0	50.0	6.7	139.7	70.0	0.0	10.0		60.0
CP6	0.0	20.0	0.0	0.0	20.0	34.0	0.0		150.0
RES1	0.0	0.0	3.5	83.6	60.0	0.0	30.0		0.0
RES2	0.0	0.0	0.6	13.9	20.0	0.0	15.0		0.0
RES4	0.0	0.0	6.7	139.7	70.0	0.0	50.0		0.0
RES3	0.0	0.0	15.0	300.0	25.0	0.0	10.0		0.0
WR7	0.0	20.0	0.0	0.0	20.0	180.0	0.0	1989	4
WR1	0.0	30.0	4.3	90.0	40.7	60.0	0.0	1989	4
WR2	0.0	0.0	1.2	32.8	20.0	20.0	0.0	1989	4
WR4	14.7	60.0	0.0	0.0	45.3	45.3	0.0	1989	4
WR6	0.0	10.0	15.0	300.0	25.0	65.3	0.0	1989	4
WR5	0.0	50.0	6.1	103.7	20.0	20.0	0.0	1989	4
WR3	0.0	15.0	0.8	18.1	0.0	0.0	0.0	1989	4
WR8	0.0	0.0	0.0	0.0	0.0	83.3	0.0	1989	4
WR9	0.0	0.0	15.0	300.0	0.0	43.3	0.0	1989	4
CP1	0.0	30.0	4.3	90.0	40.7	3.0	0.0		60.0
CP2	0.0	15.0	0.8	18.1	20.0	0.0	0.0		20.0
CP3	14.7	60.0	0.0	0.0	45.3	3.0	9.0		100.0
CP4	0.0	10.0	15.0	300.0	25.0	43.3	45.3		120.0
CP5	0.0	50.0	6.1	103.7	20.0	0.0	10.0		10.0
CP6	0.0	20.0	0.0	0.0	20.0	83.3	0.0		180.0
RES1	0.0	0.0	4.3	90.0	40.7	0.0	30.0		0.0
RES2	0.0	0.0	0.8	18.1	20.0	0.0	15.0		0.0
RES4	0.0	0.0	6.1	103.7	20.0	0.0	50.0		0.0
RES3	0.0	0.0	15.0	300.0	25.0	0.0	10.0		0.0
WR7	0.0	20.0	0.0	0.0	20.0	180.0	0.0	1989	5
WR1	0.0	30.0	4.5	90.0	34.5	60.0	0.0	1989	5
WR2	0.0	15.0	1.0	22.1	20.0	20.0	0.0	1989	5

WR4	5.5	60.0	0.0	0.0	54.5	54.5	0.0	1989	5
WR6	0.0	10.0	15.0	300.0	25.0	74.5	0.0	1989	5
WR5	0.0	50.0	4.3	69.3	20.0	20.0	0.0	1989	5
WR3	0.0	15.0	0.6	7.5	0.0	0.0	0.0	1989	5
WR8	7.5	100.0	0.0	0.0	92.5	92.5	0.0	1989	5
WR9	0.0	0.0	15.0	300.0	0.0	0.0	0.0	1989	5
CP1	0.0	30.0	4.5	90.0	34.5	0.0	0.0		60.0
CP2	0.0	30.0	0.6	7.5	20.0	0.0	0.0		20.0
CP3	5.5	60.0	0.0	0.0	54.5	0.0	12.0		100.0
CP4	0.0	10.0	15.0	300.0	25.0	0.0	54.5		120.0
CP5	0.0	50.0	4.3	69.3	20.0	0.0	10.0		10.0
CP6	7.5	120.0	0.0	0.0	112.5	0.0	0.0		180.0
RES1	0.0	0.0	4.5	90.0	34.5	0.0	30.0		0.0
RES2	0.0	0.0	0.6	7.5	20.0	0.0	30.0		0.0
RES4	0.0	0.0	4.3	69.3	20.0	0.0	50.0		0.0
RES3	0.0	0.0	15.0	300.0	25.0	0.0	10.0		0.0
WR7	0.0	20.0	0.0	0.0	20.0	226.3	0.0	1989	6
WR1	0.0	30.0	4.5	90.0	34.5	60.0	0.0	1989	6
WR2	0.0	15.0	0.5	12.0	20.0	20.0	0.0	1989	6
WR4	0.0	60.0	0.0	0.0	60.0	100.8	0.0	1989	6
WR6	0.0	10.0	15.0	300.0	25.0	120.8	0.0	1989	6
WR5	0.0	50.0	2.7	36.7	20.0	20.0	0.0	1989	6
WR3	2.7	15.0	0.2	0.0	0.0	0.0	0.0	1989	6
WR8	0.0	100.0	0.0	0.0	100.0	138.2	0.0	1989	6
WR9	0.0	0.0	15.0	300.0	0.0	38.2	0.0	1989	6
CP1	0.0	30.0	4.5	90.0	34.5	25.5	0.0		60.0
CP2	2.7	30.0	0.2	0.0	20.0	0.0	0.0		20.0
CP3	0.0	60.0	0.0	0.0	60.0	38.2	57.7		100.0
CP4	0.0	10.0	15.0	300.0	25.0	38.2	60.0		120.0
CP5	0.0	50.0	2.7	36.7	20.0	0.0	10.0		10.0
CP6	0.0	120.0	0.0	0.0	120.0	38.2	0.0		180.0
RES1	0.0	0.0	4.5	90.0	34.5	0.0	30.0		0.0
RES2	0.0	0.0	0.2	0.0	20.0	0.0	27.3		0.0
RES4	0.0	0.0	2.7	36.7	20.0	0.0	50.0		0.0
RES3	0.0	0.0	15.0	300.0	25.0	0.0	10.0		0.0
WR7	0.0	20.0	0.0	0.0	20.0	100.0	0.0	1989	7
WR1	0.0	30.0	3.9	66.1	10.0	10.0	0.0	1989	7
WR2	15.0	15.0	0.0	0.0	0.0	0.0	0.0	1989	7
WR4	0.0	60.0	0.0	0.0	60.0	76.0	0.0	1989	7
WR6	0.0	10.0	15.0	300.0	25.0	76.0	0.0	1989	7
WR5	0.0	50.0	1.1	5.6	20.0	20.0	0.0	1989	7
WR3	15.0	15.0	0.0	0.0	0.0	0.0	0.0	1989	7
WR8	49.0	100.0	0.0	0.0	51.0	51.0	0.0	1989	7
WR9	0.0	0.0	15.0	300.0	0.0	0.0	0.0	1989	7
CP1	0.0	30.0	3.9	66.1	10.0	0.0	0.0		10.0
CP2	30.0	30.0	0.0	0.0	0.0	0.0	0.0		0.0
CP3	0.0	60.0	0.0	0.0	60.0	0.0	56.0		30.0
CP4	0.0	10.0	15.0	300.0	25.0	0.0	60.0		40.0
CP5	0.0	50.0	1.1	5.6	20.0	0.0	10.0		10.0
CP6	49.0	120.0	0.0	0.0	71.0	0.0	0.0		50.0
RES1	0.0	0.0	3.9	66.1	10.0	0.0	30.0		0.0
RES2	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0

RES4	0.0	0.0	1.1	5.6	20.0	0.0	50.0		0.0
RES3	0.0	0.0	15.0	300.0	25.0	0.0	10.0		0.0
WR7	0.0	20.0	0.0	0.0	20.0	75.5	0.0	1989	8
WR1	0.0	30.0	2.7	43.4	10.0	10.0	0.0	1989	8
WR2	15.0	15.0	0.0	0.0	0.0	0.0	0.0	1989	8
WR4	8.5	60.0	0.0	0.0	51.5	51.5	0.0	1989	8
WR6	0.0	10.0	15.0	300.0	25.0	51.5	0.0	1989	8
WR5	24.5	50.0	0.1	0.0	20.0	20.0	0.0	1989	8
WR3	15.0	15.0	0.0	0.0	0.0	0.0	0.0	1989	8
WR8	73.5	100.0	0.0	0.0	26.5	26.5	0.0	1989	8
WR9	0.0	0.0	15.0	300.0	0.0	0.0	0.0	1989	8
CP1	0.0	30.0	2.7	43.4	10.0	0.0	0.0		10.0
CP2	30.0	30.0	0.0	0.0	0.0	0.0	0.0		0.0
CP3	8.5	60.0	0.0	0.0	51.5	0.0	31.5		30.0
CP4	0.0	10.0	15.0	300.0	25.0	0.0	51.5		40.0
CP5	24.5	50.0	0.1	0.0	20.0	0.0	10.0		10.0
CP6	73.5	120.0	0.0	0.0	46.5	0.0	0.0		50.0
RES1	0.0	0.0	2.7	43.4	10.0	0.0	30.0		0.0
RES2	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0
RES4	0.0	0.0	0.1	0.0	20.0	0.0	25.5		0.0
RES3	0.0	0.0	15.0	300.0	25.0	0.0	10.0		0.0
WR7	0.0	20.0	0.0	0.0	20.0	63.3	0.0	1989	9
WR1	0.0	30.0	1.6	21.7	10.0	10.0	0.0	1989	9
WR2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1989	9
WR4	20.7	60.0	0.0	0.0	39.3	39.3	0.0	1989	9
WR6	0.0	10.0	15.0	300.0	25.0	39.3	0.0	1989	9
WR5	30.0	50.0	0.0	0.0	20.0	20.0	0.0	1989	9
WR3	15.0	15.0	0.0	0.0	0.0	0.0	0.0	1989	9
WR8	0.0	0.0	0.0	0.0	0.0	14.3	0.0	1989	9
WR9	0.0	0.0	15.0	300.0	0.0	14.3	0.0	1989	9
CP1	0.0	30.0	1.6	21.7	10.0	0.0	0.0		10.0
CP2	15.0	15.0	0.0	0.0	0.0	0.0	0.0		0.0
CP3	20.7	60.0	0.0	0.0	39.3	0.0	19.3		30.0
CP4	0.0	10.0	15.0	300.0	25.0	14.3	39.3		40.0
CP5	30.0	50.0	0.0	0.0	20.0	0.0	10.0		10.0
CP6	0.0	20.0	0.0	0.0	20.0	14.3	0.0		50.0
RES1	0.0	0.0	1.6	21.7	10.0	0.0	30.0		0.0
RES2	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0
RES4	0.0	0.0	0.0	0.0	20.0	0.0	20.0		0.0
RES3	0.0	0.0	15.0	300.0	25.0	0.0	10.0		0.0
WR7	0.0	20.0	0.0	0.0	20.0	50.0	0.0	1989	10
WR1	0.0	30.0	0.6	1.2	10.0	10.0	0.0	1989	10
WR2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1989	10
WR4	34.0	60.0	0.0	0.0	26.0	26.0	0.0	1989	10
WR6	0.0	10.0	15.0	300.0	25.0	26.0	0.0	1989	10
WR5	0.0	50.0	0.9	34.2	85.0	85.0	0.0	1989	10
WR3	15.0	15.0	0.0	0.0	0.0	0.0	0.0	1989	10
WR8	0.0	0.0	0.0	0.0	0.0	1.0	0.0	1989	10
WR9	0.0	0.0	15.0	300.0	0.0	1.0	0.0	1989	10
CP1	0.0	30.0	0.6	1.2	10.0	0.0	0.0		10.0
CP2	15.0	15.0	0.0	0.0	0.0	0.0	0.0		0.0
CP3	34.0	60.0	0.0	0.0	26.0	0.0	6.0		30.0

CP4	0.0	10.0	15.0	300.0	25.0	1.0	26.0		40.0
CP5	0.0	50.0	0.9	34.2	85.0	0.0	10.0		75.0
CP6	0.0	20.0	0.0	0.0	20.0	1.0	0.0		50.0
RES1	0.0	0.0	0.6	1.2	10.0	0.0	30.0		0.0
RES2	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0
RES4	0.0	0.0	0.9	34.2	85.0	0.0	50.0		0.0
RES3	0.0	0.0	15.0	300.0	25.0	0.0	10.0		0.0
WR7	0.0	20.0	0.0	0.0	20.0	50.0	0.0	1989	11
WR1	18.9	30.0	0.0	0.0	10.0	10.0	0.0	1989	11
WR2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1989	11
WR4	37.8	60.0	0.0	0.0	22.2	22.2	0.0	1989	11
WR6	0.0	10.0	14.9	297.3	22.2	22.2	0.0	1989	11
WR5	0.0	50.0	2.5	66.7	85.0	85.0	0.0	1989	11
WR3	15.0	15.0	0.0	0.0	0.0	0.0	0.0	1989	11
WR8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1989	11
WR9	0.0	0.0	14.9	297.3	0.0	0.0	0.0	1989	11
CP1	18.9	30.0	0.0	0.0	10.0	0.0	0.0		10.0
CP2	15.0	15.0	0.0	0.0	0.0	0.0	0.0		0.0
CP3	37.8	60.0	0.0	0.0	22.2	0.0	2.2		30.0
CP4	0.0	10.0	14.9	297.3	22.2	0.0	22.2		40.0
CP5	0.0	50.0	2.5	66.7	85.0	0.0	10.0		75.0
CP6	0.0	20.0	0.0	0.0	20.0	0.0	0.0		50.0
RES1	0.0	0.0	0.0	0.0	10.0	0.0	11.1		0.0
RES2	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0
RES4	0.0	0.0	2.5	66.7	85.0	0.0	50.0		0.0
RES3	0.0	0.0	14.9	297.3	22.2	0.0	10.0		0.0
WR7	0.0	20.0	0.0	0.0	20.0	50.0	0.0	1989	12
WR1	20.0	30.0	0.0	0.0	10.0	10.0	0.0	1989	12
WR2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1989	12
WR4	38.0	60.0	0.0	0.0	22.0	22.0	0.0	1989	12
WR6	0.0	10.0	14.8	294.5	22.0	22.0	0.0	1989	12
WR5	0.0	50.0	4.1	97.6	85.0	85.0	0.0	1989	12
WR3	15.0	15.0	0.0	0.0	0.0	0.0	0.0	1989	12
WR8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1989	12
WR9	0.0	0.0	14.8	294.5	0.0	0.0	0.0	1989	12
CP1	20.0	30.0	0.0	0.0	10.0	0.0	0.0		10.0
CP2	15.0	15.0	0.0	0.0	0.0	0.0	0.0		0.0
CP3	38.0	60.0	0.0	0.0	22.0	0.0	2.0		30.0
CP4	0.0	10.0	14.8	294.5	22.0	0.0	22.0		40.0
CP5	0.0	50.0	4.1	97.6	85.0	0.0	10.0		75.0
CP6	0.0	20.0	0.0	0.0	20.0	0.0	0.0		50.0
RES1	0.0	0.0	0.0	0.0	10.0	0.0	10.0		0.0
RES2	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0
RES4	0.0	0.0	4.1	97.6	85.0	0.0	50.0		0.0
RES3	0.0	0.0	14.8	294.5	22.0	0.0	10.0		0.0

CP4	0.0	10.0	15.0	300.0	25.0	1.0	26.0		40.0
CP5	0.0	50.0	0.9	34.2	85.0	0.0	10.0		75.0
CP6	0.0	20.0	0.0	0.0	20.0	1.0	0.0		50.0
RES1	0.0	0.0	0.6	1.2	10.0	0.0	30.0		0.0
RES2	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0
RES4	0.0	0.0	0.9	34.2	85.0	0.0	50.0		0.0
RES3	0.0	0.0	15.0	300.0	25.0	0.0	10.0		0.0
WR7	0.0	20.0	0.0	0.0	20.0	50.0	0.0	1989	11
WR1	18.9	30.0	0.0	0.0	10.0	10.0	0.0	1989	11
WR2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1989	11
WR4	37.8	60.0	0.0	0.0	22.2	22.2	0.0	1989	11
WR6	0.0	10.0	14.9	297.3	22.2	22.2	0.0	1989	11
WR5	0.0	50.0	2.5	66.7	85.0	85.0	0.0	1989	11
WR3	15.0	15.0	0.0	0.0	0.0	0.0	0.0	1989	11
WR8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1989	11
WR9	0.0	0.0	14.9	297.3	0.0	0.0	0.0	1989	11
CP1	18.9	30.0	0.0	0.0	10.0	0.0	0.0		10.0
CP2	15.0	15.0	0.0	0.0	0.0	0.0	0.0		0.0
CP3	37.8	60.0	0.0	0.0	22.2	0.0	2.2		30.0
CP4	0.0	10.0	14.9	297.3	22.2	0.0	22.2		40.0
CP5	0.0	50.0	2.5	66.7	85.0	0.0	10.0		75.0
CP6	0.0	20.0	0.0	0.0	20.0	0.0	0.0		50.0
RES1	0.0	0.0	0.0	0.0	10.0	0.0	11.1		0.0
RES2	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0
RES4	0.0	0.0	2.5	66.7	85.0	0.0	50.0		0.0
RES3	0.0	0.0	14.9	297.3	22.2	0.0	10.0		0.0
WR7	0.0	20.0	0.0	0.0	20.0	50.0	0.0	1989	12
WR1	20.0	30.0	0.0	0.0	10.0	10.0	0.0	1989	12
WR2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1989	12
WR4	38.0	60.0	0.0	0.0	22.0	22.0	0.0	1989	12
WR6	0.0	10.0	14.8	294.5	22.0	22.0	0.0	1989	12
WR5	0.0	50.0	4.1	97.6	85.0	85.0	0.0	1989	12
WR3	15.0	15.0	0.0	0.0	0.0	0.0	0.0	1989	12
WR8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1989	12
WR9	0.0	0.0	14.8	294.5	0.0	0.0	0.0	1989	12
CP1	20.0	30.0	0.0	0.0	10.0	0.0	0.0		10.0
CP2	15.0	15.0	0.0	0.0	0.0	0.0	0.0		0.0
CP3	38.0	60.0	0.0	0.0	22.0	0.0	2.0		30.0
CP4	0.0	10.0	14.8	294.5	22.0	0.0	22.0		40.0
CP5	0.0	50.0	4.1	97.6	85.0	0.0	10.0		75.0
CP6	0.0	20.0	0.0	0.0	20.0	0.0	0.0		50.0
RES1	0.0	0.0	0.0	0.0	10.0	0.0	10.0		0.0
RES2	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0
RES4	0.0	0.0	4.1	97.6	85.0	0.0	50.0		0.0
RES3	0.0	0.0	14.8	294.5	22.0	0.0	10.0		0.0

SUPPLEMENT 2

WRAP3 Input File for Example 2

```
T1  TAMUWRAP MODEL DESCRIPTION AND USERS MANUAL - APPENDIX C
T2  EXAMPLE 2 - A SIMPLIFIED DATA SET IS USED TO ILLUSTRATE THE MODEL,
T3  INCLUDING WRAP3 MULTIPLE-RESERVOIR SYSTEM OPERATION FEATURES.
**
**  WRAP3 INPUT FILE FOR EXAMPLE 2
**
**  JOB CONTROL RECORD
**
JD     2      12     1988  1.0237
**
**  OUTPUT DATA FOR WATER RIGHTS (JG RECORD) AND RESERVOIRS (JR RECORD)
**
JG     4     WR1     CP2     SYS     WR7
JR    -1
**
**  MONTHLY USE FACTORS
**
UC CONST        1       1       1       1       1       1
UC              1       1       1       1       1       1
UC IRRIG        0       0       0       0    0.25    0.25
UC           0.25    0.25       0       0       0       0
**
**  CONTROL POINT RECORDS
**
CP   CP1     CP3
CP   CP2     CP3          0.08333
CP   CP3     CP4
CP   CP4     CP6
CP   CP5     OUT    0.811
CP   CP6     OUT
**
**  WATER RIGHTS AND ASSOCIATED RESERVOIR STORAGE
**
**  Water Right WR1  ---------------------------------------------------
WR   WR1     CP1     360.   CONST  192602       1      .2
WS  RES1     90.      .1      1.      0.     10.
**  Water Right WR2  ---------------------------------------------------
WR   WR2     CP2      60.   IRRIG  193908       1      .2
WS  RES2     50.      .1      1.      0.     25.
**  Water Right WR3  ---------------------------------------------------
WR   WR3     CP2     180.   CONST  196506       1      .2
WS  RES2    110.      .1      1.      0.     25.
**  Water Right WR4  ---------------------------------------------------
WR   WR4     CP3     720.   CONST  195207       2     1.0              SYS
WS  RES2    110.                             25.
OR           80.       1       1
WS  RES1     90.                             10.
OR           90.       0       1
WS  RES3    300.      .1      1.      0.     30.
OR   CP4    165.       1       1
**  Water Rights WR5a and WR5b  ----------------------------------------
WR  WR5b     CP5      0.    CONST  196213       1
WS  RES4    200.      -1                             100.
WR  WR5a     CP5    600.    CONST  196212       2                      SYS
```

```
WS  RES4    200.      -1
OR          100.       1       1      -1
WS  RES3    300.                               150.                              -1

OR          300.       0       1
**  Water Right WR6  ----------------------------------------------------
WR   WR6     CP4    120.   CONST  195704        2                        SYS
WS  RES3    300.      .1      1.      0.      30.
**  Water Right WR7  ----------------------------------------------------
WR   WR7     CP6    240.   CONST  191805        1
**  Water Right WR8  ----------------------------------------------------
WR   WR8     CP6    400.   IRRIG  197412        4     -0.5      CP3      SYS
WI    -1    300.      0.    500.    100.
WS  RES2    110.                              25.
OR           80.       1       1
WS  RES1     90.                              10.
OR           90.       0       1
WS  RES3    300.      .1      1.      0.      30.
OR          165.       1       1
**  Water Right WR9  ----------------------------------------------------
WR   WR9     CP4  24000.   CONST  197801       -1                        SYS
WS  RES3    300.                              30.                 5.     .85
**
**  STORAGE VERSUS ELEVATION TABLE FOR RESERVOIR RES3
**
PV  RES3      0.    300.
PV
PE            0.    100.
PE
**
**  STORAGE VERSUS AREA TABLE FOR RESERVOIR RES4
**
SV  RES4      0.    200.
SV
SA            0.     20.
SA
**
**  STREAMFLOW (IN) AND EVAPORATION RATE (EV) RECORDS
**
ED
IN   CP1    1988      60       60       60       60       60       60
IN                    10       10       10       10       10       10
IN   CP2    1988      20       20       20       20       20       20
IN                     0        0        0        0        0        0
IN   CP5    1988      74       74       74    12.33    12.33    12.33
IN                 12.33    12.33    12.33     92.5     92.5     92.5
IN   CP3    1988     120      120      120      100      100      100
IN                    30       30       30       30       30       30
IN   CP4    1988     120      120      120      120      120      120
IN                    40       40       40       40       40       40
IN   CP6    1988     150      150      150      180      180      180
IN                    50       50       50       50       50       50
EV   CP1    1988      .5       .5       .5       .5       .5       .5
EV                    .5       .5       .5       .5       .5       .5
```

```
IN    CP1     1989      60      60      60      60      60      60
IN                      10      10      10      10      10      10
IN    CP2     1989      20      20      20      20      20      20
IN                       0       0       0       0       0       0
IN    CP5     1989      74      74      74   12.33   12.33   12.33
IN                   12.33   12.33   12.33    92.5    92.5    92.5
IN    CP3     1989     120     120     120     100     100     100
IN                      30      30      30      30      30      30
IN    CP4     1989     120     120     120     120     120     120
IN                      40      40      40      40      40      40
IN    CP6     1989     150     150     150     180     180     180
IN                      50      50      50      50      50      50
EV    CP1     1989      .5      .5      .5      .5      .5      .5
EV                      .5      .5      .5      .5      .5      .5
EV    CP2     1989      6.      6.      6.      6.      6.      6.
EV                      6.      6.      6.      6.      6.      6.
EV    CP4    -1989     CP1
EV    CP5    -1989     CP1
**
**  END OF FILE
```

SUPPLEMENT 3

TABLES Input and Output Files for Example 1

```
TITLTAMUWRAP MODEL DESCRIPTION AND USERS MANUAL - APPENDIX C
TITLSIMULATION RESULTS FOR EXAMPLE 1 - TABLES DEVELOPED BY PROGRAM "TABLES"
COMM
COMM   TABLES INPUT FILE FOR EXAMPLE 1
COMM
COMM   Print Title Page
PAGE
COMM   Listing of Water Rights Sorted in Priority Order
1SRT   0
COMM   Water Right Summary by Control Point
1SUM   1
COMM   Reliability and Shortage Summary for All Control Points
2REL   0   0
COMM   Monthly Summary Tables
2SCP   1   0
2SWR   1   0
2SBA   2
COMM   Naturalized Streamflow (2NAT) and Unappropriated Streamflow (2UNA)
COMM   Tables
2NAT   0   0
2UNA   0   0
COMM   End of File
ENDF
```

```
**************************************************
*                                                *
*              TEXAS A&M UNIVERSITY              *
*          WATER RIGHTS ANALYSIS PACKAGE         *
*                   (TAMUWRAP)                   *
*                                                *
*      PROGRAM "WRAP3" (MARCH 1993 VERSION)      *
*      PROGRAM "TABLES" (MARCH 1993 VERSION)     *
*                                                *
**************************************************
```

```
TITLE RECORDS FROM PROGRAM "WRAP" OUTPUT FILE:

  TAMUWRAP MODEL DESCRIPTION AND USERS MANUAL - APPENDIX C
  EXAMPLE 1 - A SIMPLIFIED DATA SET IS USED TO ILLUSTRATE THE BASIC
  MODEL CAPABILITIES WHICH ARE COMMON TO BOTH WRAP2 AND WRAP3.


THE PROGRAM "WRAP" OUTPUT FILE CONTAINS SIMULATION RESULTS FOR:
      9 WATER RIGHTS
      6 CONTROL POINTS
      4 RESERVOIRS
FOR A PERIOD-OF-ANALYSIS OF  2 YEARS BEGINNING IN 1988


TITLE RECORDS FROM PROGRAM "TABLES" INPUT FILE:

TAMUWRAP MODEL DESCRIPTION AND USERS MANUAL - APPENDIX C
SIMULATION RESULTS FOR EXAMPLE 1 - TABLES DEVELOPED BY PROGRAM "TABLES"


THE PROGRAM "TABLES" INPUT FILE CONTAINS  23 RECORDS INCLUDING:
     2 JOB TYPE 1 RECORDS
     6 JOB TYPE 2 RECORDS
     0 JOB TYPE 3 RECORDS


PROGRAM "TABLES" INPUT FILE NAME:  TABLE1.DAT
PROGRAM "TABLES" OUTPUT FILE NAME: TABLE1.OUT
PROGRAM "WRAP" INPUT FILE NAME:    EXAM1.DAT
PROGRAM "WRAP" OUTPUT FILE NAME:   EXAM1.OUT
```

SIMULATION RESULTS FOR EXAMPLE 1 - TABLES DEVELOPED BY PROGRAM "TABLES"

WATER RIGHTS INPUT DATA IN PRIORITY ORDER

WATER RIGHT IDENTIFIER	PRIORITY NUMBER	CONTROL POINT IDENTIFIER	PERMITTED DIVERSION (AC-FT/YR)	STORAGE (AC-FT)	USE IDENTIFIER	TYPE	GROUP IDENTIFIER	FIRM POWER (MW/GW-HR)
WR7	191805	CP6	240.	0.	CONST	1		
WR1	192602	CP1	360.	90.	CONST	1		
WR2	193908	CP2	60.	50.	IRRIG	1		
WR4	195207	CP3	720.	0.	CONST	1	SYS	
WR6	195704	CP4	120.	300.	CONST	1	SYS	
WR5	196212	CP5	600.	200.	CONST	1	SYS	
WR3	196506	CP2	180.	110.	CONST	1		
WR8	197412	CP6	400.	0.	IRRIG	1	SYS	
WR9	197801	CP4	0.	300.	CONST	1	SYS	

TAMUWRAP MODEL DESCRIPTION AND USERS MANUAL - APPENDIX C

SIMULATION RESULTS FOR EXAMPLE 1 - TABLES DEVELOPED BY PROGRAM "TABLES"

WATER RIGHTS INPUT DATA SUMMARY BY CONTROL POINT

RESERVOIRS AND RESERVOIR STORAGE MAY BE "DOUBLE-COUNTED" IF NOT LISTED BY CONTROL POINT

CONTROL POINT	NUMBER OF RIGHTS	PERMITTED DIVERSIONS (AC-FT/YR)	NUMBER OF RESERVOIRS	RESERVOIR STORAGE (AC-FT)	PRIORITIES RANGE FROM	PRIORITIES RANGE TO
CP1	1	360.	1	90.	192602	192602
CP2	2	240.	1	110.	193908	196506
CP3	1	720.	0	0.	195207	195207
CP4	2	120.	1	300.	195704	197801
CP5	1	600.	1	200.	196212	196212
CP6	2	640.	0	0.	191805	197412
SUM	9	2680.	4	700.	191805	197801

TAMUWRAP MODEL DESCRIPTION AND USERS MANUAL - APPENDIX C

SIMULATION RESULTS FOR EXAMPLE 1 - TABLES DEVELOPED BY PROGRAM "TABLES"

RELIABILITY AND SHORTAGE SUMMARY FOR SELECTED CONTROL POINTS

NUMBER OF YEARS = 2

PERIODS PER YEAR = 12

NUMBER OF PERIODS = 24

NAME	PERMITTED DIVERSION (AC-FT/YR)	MEAN SHORTAGE (AC-FT/YR)	*RELIABILITY* PERIOD (%)	*RELIABILITY* VOLUME (%)	NUMBER OF PERIODS WITH SHORTAGES EQUALLING OR EXCEEDING PERCENT OF PERMITTED DIVERSION AMOUNT 0%	5%	10%	25%	50%	75%	100%	NUMBER OF YEARS WITH SHORTAGES EQUALLING OR EXCEEDING PERCENT OF PERMITTED DIVERSION AMOUNT 0%	2%	5%	10%	25%	50%	100%
CP1	360.0	38.9	83.33	89.19	4	4	4	4	4	0	0	2	2	2	2	0	0	0
CP2	240.0	88.8	54.17	63.02	11	11	10	10	10	9	9	2	2	2	2	1	1	0
CP3	720.0	166.4	33.33	76.89	16	15	13	8	6	0	0	2	2	2	2	1	0	0
CP4	120.0	.0	100.00	100.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CP5	600.0	31.0	87.50	94.82	3	3	3	2	1	0	0	2	1	1	0	0	0	0
CP6	640.0	121.3	75.00	81.05	6	5	4	4	2	0	0	2	2	2	2	0	0	0

SIMULATION RESULTS FOR EXAMPLE 1 - TABLES DEVELOPED BY PROGRAM "TABLES"

MONTHLY SUMMARY TABLE FOR CONTROL POINT CP1

YEAR	MONTH	NATURALIZED STREAMFLOW (ACRE-FEET)	RETURN FLOW (AC-FT)	STREAMFLOW DEPLETION (ACRE-FEET)	UNAPPROPRIATED FLOW (ACRE-FEET)	EOP STORAGE (AC-FT)	EVAPORATION (ACRE-FEET)	PERMITTED DIVERSION (AC-FT)	ACTUAL DIVERSION (AC-FT)	SHORTAGE (AC-FT)
1988	1	60.0	.0	34.5	14.5	90.0	4.5	30.0	30.0	.0
1988	2	60.0	.0	34.5	14.5	90.0	4.5	30.0	30.0	.0
1988	3	60.0	.0	34.5	14.5	90.0	4.5	30.0	30.0	.0
1988	4	60.0	.0	34.5	3.0	90.0	4.5	30.0	30.0	.0
1988	5	60.0	.0	34.5	.0	90.0	4.5	30.0	30.0	.0
1988	6	60.0	.0	34.5	25.5	90.0	4.5	30.0	30.0	.0
1988	7	10.0	.0	10.0	.0	66.1	3.9	30.0	30.0	.0
1988	8	10.0	.0	10.0	.0	43.4	2.7	30.0	30.0	.0
1988	9	10.0	.0	10.0	.0	21.7	1.6	30.0	30.0	.0
1988	10	10.0	.0	10.0	.0	1.2	.6	30.0	30.0	.0
1988	11	10.0	.0	10.0	.0	.0	.0	30.0	11.1	18.9
1988	12	10.0	.0	10.0	.0	.0	.0	30.0	10.0	20.0
1989	1	60.0	.0	60.0	.0	29.3	.7	30.0	30.0	.0
1989	2	60.0	.0	60.0	.0	57.1	2.2	30.0	30.0	.0
1989	3	60.0	.0	60.0	.0	83.6	3.5	30.0	30.0	.0
1989	4	60.0	.0	40.7	3.0	90.0	4.3	30.0	30.0	.0
1989	5	60.0	.0	34.5	.0	90.0	4.5	30.0	30.0	.0
1989	6	60.0	.0	34.5	25.5	90.0	4.5	30.0	30.0	.0
1989	7	10.0	.0	10.0	.0	66.1	3.9	30.0	30.0	.0
1989	8	10.0	.0	10.0	.0	43.4	2.7	30.0	30.0	.0
1989	9	10.0	.0	10.0	.0	21.7	1.6	30.0	30.0	.0
1989	10	10.0	.0	10.0	.0	1.2	.6	30.0	30.0	.0
1989	11	10.0	.0	10.0	.0	.0	.0	30.0	11.1	18.9
1989	12	10.0	.0	10.0	.0	.0	.0	30.0	10.0	20.0

SIMULATION RESULTS FOR EXAMPLE 1 - TABLES DEVELOPED BY PROGRAM "TABLES"

MONTHLY SUMMARY TABLE FOR CONTROL POINT CP2

YEAR	MONTH	NATURALIZED STREAMFLOW (ACRE-FEET)	RETURN FLOW (AC-FT)	STREAMFLOW DEPLETION (ACRE-FEET)	UNAPPROPRIATED FLOW (ACRE-FEET)	EOP STORAGE (AC-FT)	EVAPORATION (ACRE-FEET)	PERMITTED DIVERSION (AC-FT)	ACTUAL DIVERSION (AC-FT)	SHORTAGE (AC-FT)
1988	1	20.0	.0	20.0	.0	109.5	5.5	15.0	15.0	.0
1988	2	20.0	.0	20.0	.0	109.0	5.5	15.0	15.0	.0
1988	3	20.0	.0	20.0	.0	108.6	5.4	15.0	15.0	.0
1988	4	20.0	.0	11.5	3.0	99.9	5.2	15.0	15.0	.0
1988	5	20.0	.0	17.5	.0	82.8	4.6	30.0	30.0	.0
1988	6	20.0	.0	20.0	.0	69.0	3.8	30.0	30.0	.0
1988	7	.0	.0	.0	.0	36.4	2.6	30.0	30.0	.0
1988	8	.0	.0	.0	.0	5.4	1.0	30.0	30.0	.0
1988	9	.0	.0	.0	.0	.0	.1	15.0	5.2	9.8
1988	10	.0	.0	.0	.0	.0	.0	15.0	.0	15.0
1988	11	.0	.0	.0	.0	.0	.0	15.0	.0	15.0
1988	12	.0	.0	.0	.0	.0	.0	15.0	.0	15.0
1989	1	20.0	.0	20.0	.0	4.9	.1	15.0	15.0	.0
1989	2	20.0	.0	20.0	.0	9.5	.4	15.0	15.0	.0
1989	3	20.0	.0	20.0	.0	13.9	.6	15.0	15.0	.0
1989	4	20.0	.0	20.0	.0	18.1	.8	15.0	15.0	.0
1989	5	20.0	.0	20.0	.0	7.5	.6	30.0	30.0	.0
1989	6	20.0	.0	20.0	.0	.0	.2	30.0	27.3	2.7
1989	7	.0	.0	.0	.0	.0	.0	30.0	.0	30.0
1989	8	.0	.0	.0	.0	.0	.0	30.0	.0	30.0
1989	9	.0	.0	.0	.0	.0	.0	15.0	.0	15.0
1989	10	.0	.0	.0	.0	.0	.0	15.0	.0	15.0
1989	11	.0	.0	.0	.0	.0	.0	15.0	.0	15.0
1989	12	.0	.0	.0	.0	.0	.0	15.0	.0	15.0

TAMUWRAP MODEL DESCRIPTION AND USERS MANUAL - APPENDIX C

SIMULATION RESULTS FOR EXAMPLE 1 - TABLES DEVELOPED BY PROGRAM "TABLES"

MONTHLY SUMMARY TABLE FOR CONTROL POINT CP3

YEAR	MONTH	NATURALIZED STREAMFLOW (ACRE-FEET)	RETURN FLOW (AC-FT)	STREAMFLOW DEPLETION (ACRE-FEET)	UNAPPROPRIATED FLOW (ACRE-FEET)	EOP STORAGE (AC-FT)	EVAPORATION (ACRE-FEET)	PERMITTED DIVERSION (AC-FT)	ACTUAL DIVERSION (AC-FT)	SHORTAGE (AC-FT)
1988	1	120.0	9.0	60.0	14.5	.0	.0	60.0	60.0	.0
1988	2	120.0	9.0	60.0	14.5	.0	.0	60.0	60.0	.0
1988	3	120.0	9.0	60.0	14.5	.0	.0	60.0	60.0	.0
1988	4	100.0	9.0	60.0	3.0	.0	.0	60.0	60.0	.0
1988	5	100.0	12.0	57.0	.0	.0	.0	60.0	57.0	3.0
1988	6	100.0	59.5	60.0	40.0	.0	.0	60.0	60.0	.0
1988	7	30.0	62.0	60.0	.0	.0	.0	60.0	60.0	.0
1988	8	30.0	40.5	57.5	.0	.0	.0	60.0	57.5	2.5
1988	9	30.0	24.8	43.8	1.0	.0	.0	60.0	43.7	16.3
1988	10	30.0	6.0	26.0	.0	.0	.0	60.0	26.0	34.0
1988	11	30.0	2.2	22.2	.0	.0	.0	60.0	22.2	37.8
1988	12	30.0	2.0	22.0	.0	.0	.0	60.0	22.0	38.0
1989	1	120.0	9.0	46.0	3.0	.0	.0	60.0	46.0	14.0
1989	2	120.0	9.0	46.0	3.0	.0	.0	60.0	46.0	14.0
1989	3	120.0	9.0	46.0	3.0	.0	.0	60.0	46.0	14.0
1989	4	100.0	9.0	45.3	3.0	.0	.0	60.0	45.3	14.7
1989	5	100.0	12.0	54.5	.0	.0	.0	60.0	54.5	5.5
1989	6	100.0	57.7	60.0	38.2	.0	.0	60.0	60.0	.0
1989	7	30.0	56.0	60.0	.0	.0	.0	60.0	60.0	.0
1989	8	30.0	31.5	51.5	.0	.0	.0	60.0	51.5	8.5
1989	9	30.0	19.3	39.3	.0	.0	.0	60.0	39.3	20.7
1989	10	30.0	6.0	26.0	.0	.0	.0	60.0	26.0	34.0
1989	11	30.0	2.2	22.2	.0	.0	.0	60.0	22.2	37.8
1989	12	30.0	2.0	22.0	.0	.0	.0	60.0	22.0	38.0

MONTHLY SUMMARY TABLE FOR CONTROL POINT CP4

YEAR	MONTH	NATURALIZED STREAMFLOW (ACRE-FEET)	RETURN FLOW (AC-FT)	STREAMFLOW DEPLETION (ACRE-FEET)	UNAPPROPRIATED FLOW (ACRE-FEET)	EOP STORAGE (AC-FT)	EVAPORATION (ACRE-FEET)	PERMITTED DIVERSION (AC-FT)	ACTUAL DIVERSION (AC-FT)	SHORTAGE (AC-FT)
1988	1	120.0	60.0	25.0	49.5	300.0	15.0	10.0	10.0	.0
1988	2	120.0	60.0	25.0	49.5	300.0	15.0	10.0	10.0	.0
1988	3	120.0	60.0	25.0	49.5	300.0	15.0	10.0	10.0	.0
1988	4	120.0	60.0	25.0	58.0	300.0	15.0	10.0	10.0	.0
1988	5	120.0	57.0	25.0	.0	300.0	15.0	10.0	10.0	.0
1988	6	120.0	60.0	25.0	40.0	300.0	15.0	10.0	10.0	.0
1988	7	40.0	60.0	25.0	.0	300.0	15.0	10.0	10.0	.0
1988	8	40.0	57.5	25.0	.0	300.0	15.0	10.0	10.0	.0
1988	9	40.0	43.8	25.0	19.8	300.0	15.0	10.0	10.0	.0
1988	10	40.0	26.0	25.0	1.0	300.0	15.0	10.0	10.0	.0
1988	11	40.0	22.2	22.2	.0	297.3	14.9	10.0	10.0	.0
1988	12	40.0	22.0	22.0	.0	294.5	14.8	10.0	10.0	.0
1989	1	120.0	46.0	30.4	18.6	300.0	14.9	10.0	10.0	.0
1989	2	120.0	46.0	25.0	24.0	300.0	15.0	10.0	10.0	.0
1989	3	120.0	46.0	25.0	24.0	300.0	15.0	10.0	10.0	.0
1989	4	120.0	45.3	25.0	43.3	300.0	15.0	10.0	10.0	.0
1989	5	120.0	54.5	25.0	.0	300.0	15.0	10.0	10.0	.0
1989	6	120.0	60.0	25.0	38.2	300.0	15.0	10.0	10.0	.0
1989	7	40.0	60.0	25.0	.0	300.0	15.0	10.0	10.0	.0
1989	8	40.0	51.5	25.0	.0	300.0	15.0	10.0	10.0	.0
1989	9	40.0	39.3	25.0	14.3	300.0	15.0	10.0	10.0	.0
1989	10	40.0	26.0	25.0	1.0	300.0	15.0	10.0	10.0	.0
1989	11	40.0	22.2	22.2	.0	297.3	14.9	10.0	10.0	.0
1989	12	40.0	22.0	22.0	.0	294.5	14.8	10.0	10.0	.0

SIMULATION RESULTS FOR EXAMPLE 1 - TABLES DEVELOPED BY PROGRAM "TABLES"

MONTHLY SUMMARY TABLE FOR CONTROL POINT CP5

YEAR	MONTH	NATURALIZED STREAMFLOW (ACRE-FEET)	RETURN FLOW (AC-FT)	STREAMFLOW DEPLETION (ACRE-FEET)	UNAPPROPRIATED FLOW (ACRE-FEET)	EOP STORAGE (AC-FT)	EVAPORATION (ACRE-FEET)	PERMITTED DIVERSION (AC-FT)	ACTUAL DIVERSION (AC-FT)	SHORTAGE (AC-FT)
1988	1	60.0	10.0	60.0	10.0	200.0	10.0	50.0	50.0	.0
1988	2	60.0	10.0	60.0	10.0	200.0	10.0	50.0	50.0	.0
1988	3	60.0	10.0	60.0	10.0	200.0	10.0	50.0	50.0	.0
1988	4	10.0	10.0	20.0	.0	161.0	9.0	50.0	50.0	.0
1988	5	10.0	10.0	20.0	.0	123.9	7.1	50.0	50.0	.0
1988	6	10.0	10.0	20.0	.0	88.5	5.3	50.0	50.0	.0
1988	7	10.0	10.0	20.0	.0	55.0	3.6	50.0	50.0	.0
1988	8	10.0	10.0	20.0	.0	23.0	1.9	50.0	50.0	.0
1988	9	10.0	10.0	20.0	.0	.0	.6	50.0	42.4	7.6
1988	10	75.0	10.0	85.0	.0	34.2	.9	50.0	50.0	.0
1988	11	75.0	10.0	85.0	.0	66.7	2.5	50.0	50.0	.0
1988	12	75.0	10.0	85.0	.0	97.6	4.1	50.0	50.0	.0
1989	1	60.0	10.0	70.0	.0	112.3	5.2	50.0	50.0	.0
1989	2	60.0	10.0	70.0	.0	126.4	6.0	50.0	50.0	.0
1989	3	60.0	10.0	70.0	.0	139.7	6.7	50.0	50.0	.0
1989	4	10.0	10.0	20.0	.0	103.7	6.1	50.0	50.0	.0
1989	5	10.0	10.0	20.0	.0	69.3	4.3	50.0	50.0	.0
1989	6	10.0	10.0	20.0	.0	36.7	2.7	50.0	50.0	.0
1989	7	10.0	10.0	20.0	.0	5.6	1.1	50.0	50.0	.0
1989	8	10.0	10.0	20.0	.0	.0	.1	50.0	25.5	24.5
1989	9	10.0	10.0	20.0	.0	.0	.0	50.0	20.0	30.0
1989	10	75.0	10.0	85.0	.0	34.2	.9	50.0	50.0	.0
1989	11	75.0	10.0	85.0	.0	66.7	2.5	50.0	50.0	.0
1989	12	75.0	10.0	85.0	.0	97.6	4.1	50.0	50.0	.0

SIMULATION RESULTS FOR EXAMPLE 1 - TABLES DEVELOPED BY PROGRAM "TABLES"

MONTHLY SUMMARY TABLE FOR CONTROL POINT CP6

YEAR	MONTH	NATURALIZED STREAMFLOW (ACRE-FEET)	RETURN FLOW (AC-FT)	STREAMFLOW DEPLETION (ACRE-FEET)	UNAPPROPRIATED FLOW (ACRE-FEET)	EOP STORAGE (AC-FT)	EVAPORATION (ACRE-FEET)	PERMITTED DIVERSION (AC-FT)	ACTUAL DIVERSION (AC-FT)	SHORTAGE (AC-FT)
1988	1	150.0	.0	20.0	59.5	.0	.0	20.0	20.0	.0
1988	2	150.0	.0	20.0	59.5	.0	.0	20.0	20.0	.0
1988	3	150.0	.0	20.0	59.5	.0	.0	20.0	20.0	.0
1988	4	180.0	.0	20.0	98.0	.0	.0	20.0	20.0	.0
1988	5	180.0	.0	115.0	.0	.0	.0	120.0	115.0	5.0
1988	6	180.0	.0	120.0	40.0	.0	.0	120.0	120.0	.0
1988	7	50.0	.0	77.0	.0	.0	.0	120.0	77.0	43.0
1988	8	50.0	.0	55.5	.0	.0	.0	120.0	55.5	64.5
1988	9	50.0	.0	20.0	19.8	.0	.0	20.0	20.0	.0
1988	10	50.0	.0	20.0	1.0	.0	.0	20.0	20.0	.0
1988	11	50.0	.0	20.0	.0	.0	.0	20.0	20.0	.0
1988	12	50.0	.0	20.0	.0	.0	.0	20.0	20.0	.0
1989	1	150.0	.0	20.0	28.6	.0	.0	20.0	20.0	.0
1989	2	150.0	.0	20.0	34.0	.0	.0	20.0	20.0	.0
1989	3	150.0	.0	20.0	34.0	.0	.0	20.0	20.0	.0
1989	4	180.0	.0	20.0	83.3	.0	.0	20.0	20.0	.0
1989	5	180.0	.0	112.5	.0	.0	.0	120.0	112.5	7.5
1989	6	180.0	.0	120.0	38.2	.0	.0	120.0	120.0	.0
1989	7	50.0	.0	71.0	.0	.0	.0	120.0	71.0	49.0
1989	8	50.0	.0	46.5	.0	.0	.0	120.0	46.5	73.5
1989	9	50.0	.0	20.0	14.3	.0	.0	20.0	20.0	.0
1989	10	50.0	.0	20.0	1.0	.0	.0	20.0	20.0	.0
1989	11	50.0	.0	20.0	.0	.0	.0	20.0	20.0	.0
1989	12	50.0	.0	20.0	.0	.0	.0	20.0	20.0	.0

SIMULATION RESULTS FOR EXAMPLE 1 - TABLES DEVELOPED BY PROGRAM "TABLES"

MONTHLY SUMMARY TABLE FOR WATER RIGHT WR7

YEAR	MONTH	AVAILABLE STREAMFLOW (ACRE-FEET)	STREAMFLOW DEPLETION (ACRE-FEET)	EOP STORAGE (AC-FT)	EVAPORATION (AC-FT)	SYSTEM RELEASES (ACRE-FEET)	PERMITTED DIVERSION (AC-FT)	ACTUAL DIVERSION (AC-FT)	SHORTAGE (AC-FT)
1988	1	150.0	20.0	.0	.0	.0	20.0	20.0	.0
1988	2	150.0	20.0	.0	.0	.0	20.0	20.0	.0
1988	3	150.0	20.0	.0	.0	.0	20.0	20.0	.0
1988	4	180.0	20.0	.0	.0	.0	20.0	20.0	.0
1988	5	180.0	20.0	.0	.0	.0	20.0	20.0	.0
1988	6	227.5	20.0	.0	.0	.0	20.0	20.0	.0
1988	7	100.0	20.0	.0	.0	.0	20.0	20.0	.0
1988	8	78.5	20.0	.0	.0	.0	20.0	20.0	.0
1988	9	67.8	20.0	.0	.0	.0	20.0	20.0	.0
1988	10	50.0	20.0	.0	.0	.0	20.0	20.0	.0
1988	11	50.0	20.0	.0	.0	.0	20.0	20.0	.0
1988	12	50.0	20.0	.0	.0	.0	20.0	20.0	.0
1989	1	150.0	20.0	.0	.0	.0	20.0	20.0	.0
1989	2	150.0	20.0	.0	.0	.0	20.0	20.0	.0
1989	3	150.0	20.0	.0	.0	.0	20.0	20.0	.0
1989	4	180.0	20.0	.0	.0	.0	20.0	20.0	.0
1989	5	180.0	20.0	.0	.0	.0	20.0	20.0	.0
1989	6	226.3	20.0	.0	.0	.0	20.0	20.0	.0
1989	7	100.0	20.0	.0	.0	.0	20.0	20.0	.0
1989	8	75.5	20.0	.0	.0	.0	20.0	20.0	.0
1989	9	63.3	20.0	.0	.0	.0	20.0	20.0	.0
1989	10	50.0	20.0	.0	.0	.0	20.0	20.0	.0
1989	11	50.0	20.0	.0	.0	.0	20.0	20.0	.0
1989	12	50.0	20.0	.0	.0	.0	20.0	20.0	.0

SIMULATION RESULTS FOR EXAMPLE 1 - TABLES DEVELOPED BY PROGRAM "TABLES"

MONTHLY SUMMARY TABLE FOR WATER RIGHT WR1

YEAR	MONTH	AVAILABLE STREAMFLOW (ACRE-FEET)	STREAMFLOW DEPLETION (ACRE-FEET)	EOP STORAGE (AC-FT)	EVAPORATION (AC-FT)	SYSTEM RELEASES (ACRE-FEET)	PERMITTED DIVERSION (AC-FT)	ACTUAL DIVERSION (AC-FT)	SHORTAGE (AC-FT)
1988	1	60.0	34.5	90.0	4.5	.0	30.0	30.0	.0
1988	2	60.0	34.5	90.0	4.5	.0	30.0	30.0	.0
1988	3	60.0	34.5	90.0	4.5	.0	30.0	30.0	.0
1988	4	60.0	34.5	90.0	4.5	.0	30.0	30.0	.0
1988	5	60.0	34.5	90.0	4.5	.0	30.0	30.0	.0
1988	6	60.0	34.5	90.0	4.5	.0	30.0	30.0	.0
1988	7	10.0	10.0	66.1	3.9	.0	30.0	30.0	.0
1988	8	10.0	10.0	43.4	2.7	.0	30.0	30.0	.0
1988	9	10.0	10.0	21.7	1.6	.0	30.0	30.0	.0
1988	10	10.0	10.0	1.2	.6	.0	30.0	30.0	.0
1988	11	10.0	10.0	.0	.0	.0	30.0	11.1	18.9
1988	12	10.0	10.0	.0	.0	.0	30.0	10.0	20.0
1989	1	60.0	60.0	29.3	.7	.0	30.0	30.0	.0
1989	2	60.0	60.0	57.1	2.2	.0	30.0	30.0	.0
1989	3	60.0	60.0	83.6	3.5	.0	30.0	30.0	.0
1989	4	60.0	40.7	90.0	4.3	.0	30.0	30.0	.0
1989	5	60.0	34.5	90.0	4.5	.0	30.0	30.0	.0
1989	6	60.0	34.5	90.0	4.5	.0	30.0	30.0	.0
1989	7	10.0	10.0	66.1	3.9	.0	30.0	30.0	.0
1989	8	10.0	10.0	43.4	2.7	.0	30.0	30.0	.0
1989	9	10.0	10.0	21.7	1.6	.0	30.0	30.0	.0
1989	10	10.0	10.0	1.2	.6	.0	30.0	30.0	.0
1989	11	10.0	10.0	.0	.0	.0	30.0	11.1	18.9
1989	12	10.0	10.0	.0	.0	.0	30.0	10.0	20.0

SIMULATION RESULTS FOR EXAMPLE 1 - TABLES DEVELOPED BY PROGRAM "TABLES"

MONTHLY SUMMARY TABLE FOR WATER RIGHT WR2

YEAR	MONTH	AVAILABLE STREAMFLOW (ACRE-FEET)	STREAMFLOW DEPLETION (ACRE-FEET)	EOP STORAGE (AC-FT)	EVAPORATION (AC-FT)	SYSTEM RELEASES (ACRE-FEET)	PERMITTED DIVERSION (AC-FT)	ACTUAL DIVERSION (AC-FT)	SHORTAGE (AC-FT)
1988	1	20.0	2.5	50.0	2.5	.0	.0	.0	.0
1988	2	20.0	2.5	50.0	2.5	.0	.0	.0	.0
1988	3	20.0	2.5	50.0	2.5	.0	.0	.0	.0
1988	4	20.0	2.5	50.0	2.5	.0	.0	.0	.0
1988	5	20.0	17.5	50.0	2.5	.0	15.0	15.0	.0
1988	6	20.0	17.5	50.0	2.5	.0	15.0	15.0	.0
1988	7	.0	.0	32.9	2.1	.0	15.0	15.0	.0
1988	8	.0	.0	20.0	1.4	.0	15.0	15.0	.0
1988	9	.0	.0	5.1	.3	.0	.0	.0	.0
1988	10	.0	.0	.0	.0	.0	.0	.0	.0
1988	11	.0	.0	.0	.0	.0	.0	.0	.0
1988	12	.0	.0	.0	.0	.0	.0	.0	.0
1989	1	20.0	20.0	19.5	.5	.0	.0	.0	.0
1989	2	20.0	20.0	24.2	.7	.0	.0	.0	.0
1989	3	20.0	20.0	28.6	1.0	.0	.0	.0	.0
1989	4	20.0	20.0	32.8	1.2	.0	.0	.0	.0
1989	5	20.0	20.0	22.1	1.0	.0	15.0	15.0	.0
1989	6	20.0	20.0	12.0	.5	.0	15.0	15.0	.0
1989	7	.0	.0	.0	.0	.0	15.0	.0	15.0
1989	8	.0	.0	.0	.0	.0	15.0	.0	15.0
1989	9	.0	.0	.0	.0	.0	.0	.0	.0
1989	10	.0	.0	.0	.0	.0	.0	.0	.0
1989	11	.0	.0	.0	.0	.0	.0	.0	.0
1989	12	.0	.0	.0	.0	.0	.0	.0	.0

SIMULATION RESULTS FOR EXAMPLE 1 - TABLES DEVELOPED BY PROGRAM "TABLES"

MONTHLY SUMMARY TABLE FOR WATER RIGHT WR4

YEAR	MONTH	AVAILABLE STREAMFLOW (ACRE-FEET)	STREAMFLOW DEPLETION (ACRE-FEET)	EOP STORAGE (AC-FT)	EVAPORATION (AC-FT)	SYSTEM RELEASES (ACRE-FEET)	PERMITTED DIVERSION (AC-FT)	ACTUAL DIVERSION (AC-FT)	SHORTAGE (AC-FT)
1988	1	89.0	60.0	.0	.0	.0	60.0	60.0	.0
1988	2	89.0	60.0	.0	.0	.0	60.0	60.0	.0
1988	3	89.0	60.0	.0	.0	.0	60.0	60.0	.0
1988	4	69.0	60.0	.0	.0	.0	60.0	60.0	.0
1988	5	57.0	57.0	.0	.0	.0	60.0	57.0	3.0
1988	6	104.5	60.0	.0	.0	.0	60.0	60.0	.0
1988	7	79.0	60.0	.0	.0	.0	60.0	60.0	.0
1988	8	57.5	57.5	.0	.0	.0	60.0	57.5	2.5
1988	9	43.8	43.8	.0	.0	.0	60.0	43.7	16.3
1988	10	26.0	26.0	.0	.0	.0	60.0	26.0	34.0
1988	11	22.2	22.2	.0	.0	.0	60.0	22.2	37.8
1988	12	22.0	22.0	.0	.0	.0	60.0	22.0	38.0
1989	1	46.0	46.0	.0	.0	.0	60.0	46.0	14.0
1989	2	46.0	46.0	.0	.0	.0	60.0	46.0	14.0
1989	3	46.0	46.0	.0	.0	.0	60.0	46.0	14.0
1989	4	45.3	45.3	.0	.0	.0	60.0	45.3	14.7
1989	5	54.5	54.5	.0	.0	.0	60.0	54.5	5.5
1989	6	100.8	60.0	.0	.0	.0	60.0	60.0	.0
1989	7	76.0	60.0	.0	.0	.0	60.0	60.0	.0
1989	8	51.5	51.5	.0	.0	.0	60.0	51.5	8.5
1989	9	39.3	39.3	.0	.0	.0	60.0	39.3	20.7
1989	10	26.0	26.0	.0	.0	.0	60.0	26.0	34.0
1989	11	22.2	22.2	.0	.0	.0	60.0	22.2	37.8
1989	12	22.0	22.0	.0	.0	.0	60.0	22.0	38.0

SIMULATION RESULTS FOR EXAMPLE 1 - TABLES DEVELOPED BY PROGRAM "TABLES"

MONTHLY SUMMARY TABLE FOR WATER RIGHT WR6

YEAR	MONTH	AVAILABLE STREAMFLOW (ACRE-FEET)	STREAMFLOW DEPLETION (ACRE-FEET)	EOP STORAGE (AC-FT)	EVAPORATION (AC-FT)	SYSTEM RELEASES (ACRE-FEET)	PERMITTED DIVERSION (AC-FT)	ACTUAL DIVERSION (AC-FT)	SHORTAGE (AC-FT)
1988	1	89.0	25.0	300.0	15.0	.0	10.0	10.0	.0
1988	2	89.0	25.0	300.0	15.0	.0	10.0	10.0	.0
1988	3	89.0	25.0	300.0	15.0	.0	10.0	10.0	.0
1988	4	89.0	25.0	300.0	15.0	.0	10.0	10.0	.0
1988	5	77.0	25.0	300.0	15.0	.0	10.0	10.0	.0
1988	6	124.5	25.0	300.0	15.0	.0	10.0	10.0	.0
1988	7	79.0	25.0	300.0	15.0	.0	10.0	10.0	.0
1988	8	57.5	25.0	300.0	15.0	.0	10.0	10.0	.0
1988	9	43.8	25.0	300.0	15.0	.0	10.0	10.0	.0
1988	10	26.0	25.0	300.0	15.0	.0	10.0	10.0	.0
1988	11	22.2	22.2	297.3	14.9	.0	10.0	10.0	.0
1988	12	22.0	22.0	294.5	14.8	.0	10.0	10.0	.0
1989	1	46.0	30.4	300.0	14.9	.0	10.0	10.0	.0
1989	2	46.0	25.0	300.0	15.0	.0	10.0	10.0	.0
1989	3	46.0	25.0	300.0	15.0	.0	10.0	10.0	.0
1989	4	65.3	25.0	300.0	15.0	.0	10.0	10.0	.0
1989	5	74.5	25.0	300.0	15.0	.0	10.0	10.0	.0
1989	6	120.8	25.0	300.0	15.0	.0	10.0	10.0	.0
1989	7	76.0	25.0	300.0	15.0	.0	10.0	10.0	.0
1989	8	51.5	25.0	300.0	15.0	.0	10.0	10.0	.0
1989	9	39.3	25.0	300.0	15.0	.0	10.0	10.0	.0
1989	10	26.0	25.0	300.0	15.0	.0	10.0	10.0	.0
1989	11	22.2	22.2	297.3	14.9	.0	10.0	10.0	.0
1989	12	22.0	22.0	294.5	14.8	.0	10.0	10.0	.0

SIMULATION RESULTS FOR EXAMPLE 1 - TABLES DEVELOPED BY PROGRAM "TABLES"

MONTHLY SUMMARY TABLE FOR WATER RIGHT WR5

YEAR	MONTH	AVAILABLE STREAMFLOW (ACRE-FEET)	STREAMFLOW DEPLETION (ACRE-FEET)	EOP STORAGE (AC-FT)	EVAPORATION (AC-FT)	SYSTEM RELEASES (ACRE-FEET)	PERMITTED DIVERSION (AC-FT)	ACTUAL DIVERSION (AC-FT)	SHORTAGE (AC-FT)
1988	1	70.0	60.0	200.0	10.0	.0	50.0	50.0	.0
1988	2	70.0	60.0	200.0	10.0	.0	50.0	50.0	.0
1988	3	70.0	60.0	200.0	10.0	.0	50.0	50.0	.0
1988	4	20.0	20.0	161.0	9.0	.0	50.0	50.0	.0
1988	5	20.0	20.0	123.9	7.1	.0	50.0	50.0	.0
1988	6	20.0	20.0	88.5	5.3	.0	50.0	50.0	.0
1988	7	20.0	20.0	55.0	3.6	.0	50.0	50.0	.0
1988	8	20.0	20.0	23.0	1.9	.0	50.0	50.0	.0
1988	9	20.0	20.0	.0	.6	.0	50.0	42.4	7.6
1988	10	85.0	85.0	34.2	.9	.0	50.0	50.0	.0
1988	11	85.0	85.0	66.7	2.5	.0	50.0	50.0	.0
1988	12	85.0	85.0	97.6	4.1	.0	50.0	50.0	.0
1989	1	70.0	70.0	112.3	5.2	.0	50.0	50.0	.0
1989	2	70.0	70.0	126.4	6.0	.0	50.0	50.0	.0
1989	3	70.0	70.0	139.7	6.7	.0	50.0	50.0	.0
1989	4	20.0	20.0	103.7	6.1	.0	50.0	50.0	.0
1989	5	20.0	20.0	69.3	4.3	.0	50.0	50.0	.0
1989	6	20.0	20.0	36.7	2.7	.0	50.0	50.0	.0
1989	7	20.0	20.0	5.6	1.1	.0	50.0	50.0	.0
1989	8	20.0	20.0	.0	.1	.0	50.0	25.5	24.5
1989	9	20.0	20.0	.0	.0	.0	50.0	20.0	30.0
1989	10	85.0	85.0	34.2	.9	.0	50.0	50.0	.0
1989	11	85.0	85.0	66.7	2.5	.0	50.0	50.0	.0
1989	12	85.0	85.0	97.6	4.1	.0	50.0	50.0	.0

MONTHLY SUMMARY TABLE FOR WATER RIGHT WR3

YEAR	MONTH	AVAILABLE STREAMFLOW (ACRE-FEET)	STREAMFLOW DEPLETION (ACRE-FEET)	EOP STORAGE (AC-FT)	EVAPORATION (AC-FT)	SYSTEM RELEASES (ACRE-FEET)	PERMITTED DIVERSION (AC-FT)	ACTUAL DIVERSION (AC-FT)	SHORTAGE (AC-FT)
1988	1	17.5	17.5	109.5	5.5	.0	15.0	15.0	.0
1988	2	17.5	17.5	109.0	5.5	.0	15.0	15.0	.0
1988	3	17.5	17.5	108.6	5.4	.0	15.0	15.0	.0
1988	4	9.0	9.0	99.9	5.2	.0	15.0	15.0	.0
1988	5	.0	.0	82.8	4.6	.0	15.0	15.0	.0
1988	6	2.5	2.5	69.0	3.8	.0	15.0	15.0	.0
1988	7	.0	.0	36.4	2.6	.0	15.0	15.0	.0
1988	8	.0	.0	5.4	1.0	.0	15.0	15.0	.0
1988	9	.0	.0	.0	.1	.0	15.0	5.2	9.8
1988	10	.0	.0	.0	.0	.0	15.0	.0	15.0
1988	11	.0	.0	.0	.0	.0	15.0	.0	15.0
1988	12	.0	.0	.0	.0	.0	15.0	.0	15.0
1989	1	.0	.0	4.9	.1	.0	15.0	15.0	.0
1989	2	.0	.0	9.5	.4	.0	15.0	15.0	.0
1989	3	.0	.0	13.9	.6	.0	15.0	15.0	.0
1989	4	.0	.0	18.1	.8	.0	15.0	15.0	.0
1989	5	.0	.0	7.5	.6	.0	15.0	15.0	.0
1989	6	.0	.0	.0	.2	.0	15.0	12.3	2.7
1989	7	.0	.0	.0	.0	.0	15.0	.0	15.0
1989	8	.0	.0	.0	.0	.0	15.0	.0	15.0
1989	9	.0	.0	.0	.0	.0	15.0	.0	15.0
1989	10	.0	.0	.0	.0	.0	15.0	.0	15.0
1989	11	.0	.0	.0	.0	.0	15.0	.0	15.0
1989	12	.0	.0	.0	.0	.0	15.0	.0	15.0

SIMULATION RESULTS FOR EXAMPLE 1 - TABLES DEVELOPED BY PROGRAM "TABLES"

MONTHLY SUMMARY TABLE FOR WATER RIGHT WR8

YEAR	MONTH	AVAILABLE STREAMFLOW (ACRE-FEET)	STREAMFLOW DEPLETION (ACRE-FEET)	EOP STORAGE (AC-FT)	EVAPORATION (AC-FT)	SYSTEM RELEASES (ACRE-FEET)	PERMITTED DIVERSION (AC-FT)	ACTUAL DIVERSION (AC-FT)	SHORTAGE (AC-FT)
1988	1	59.5	.0	.0	.0	.0	.0	.0	.0
1988	2	59.5	.0	.0	.0	.0	.0	.0	.0
1988	3	59.5	.0	.0	.0	.0	.0	.0	.0
1988	4	98.0	.0	.0	.0	.0	.0	.0	.0
1988	5	95.0	95.0	.0	.0	.0	100.0	95.0	5.0
1988	6	140.0	100.0	.0	.0	.0	100.0	100.0	.0
1988	7	57.0	57.0	.0	.0	.0	100.0	57.0	43.0
1988	8	35.5	35.5	.0	.0	.0	100.0	35.5	64.5
1988	9	19.8	.0	.0	.0	.0	.0	.0	.0
1988	10	1.0	.0	.0	.0	.0	.0	.0	.0
1988	11	.0	.0	.0	.0	.0	.0	.0	.0
1988	12	.0	.0	.0	.0	.0	.0	.0	.0
1989	1	28.6	.0	.0	.0	.0	.0	.0	.0
1989	2	34.0	.0	.0	.0	.0	.0	.0	.0
1989	3	34.0	.0	.0	.0	.0	.0	.0	.0
1989	4	83.3	.0	.0	.0	.0	.0	.0	.0
1989	5	92.5	92.5	.0	.0	.0	100.0	92.5	7.5
1989	6	138.2	100.0	.0	.0	.0	100.0	100.0	.0
1989	7	51.0	51.0	.0	.0	.0	100.0	51.0	49.0
1989	8	26.5	26.5	.0	.0	.0	100.0	26.5	73.5
1989	9	14.3	.0	.0	.0	.0	.0	.0	.0
1989	10	1.0	.0	.0	.0	.0	.0	.0	.0
1989	11	.0	.0	.0	.0	.0	.0	.0	.0
1989	12	.0	.0	.0	.0	.0	.0	.0	.0

SIMULATION RESULTS FOR EXAMPLE 1 - TABLES DEVELOPED BY PROGRAM "TABLES"

MONTHLY SUMMARY TABLE FOR WATER RIGHT WR9

YEAR	MONTH	AVAILABLE STREAMFLOW (ACRE-FEET)	STREAMFLOW DEPLETION (ACRE-FEET)	EOP STORAGE (AC-FT)	EVAPORATION (AC-FT)	SYSTEM RELEASES (ACRE-FEET)	PERMITTED DIVERSION (AC-FT)	ACTUAL DIVERSION (AC-FT)	SHORTAGE (AC-FT)
1988	1	49.5	.0	300.0	15.0	.0	.0	.0	.0
1988	2	49.5	.0	300.0	15.0	.0	.0	.0	.0
1988	3	49.5	.0	300.0	15.0	.0	.0	.0	.0
1988	4	58.0	.0	300.0	15.0	.0	.0	.0	.0
1988	5	.0	.0	300.0	15.0	.0	.0	.0	.0
1988	6	40.0	.0	300.0	15.0	.0	.0	.0	.0
1988	7	.0	.0	300.0	15.0	.0	.0	.0	.0
1988	8	.0	.0	300.0	15.0	.0	.0	.0	.0
1988	9	19.8	.0	300.0	15.0	.0	.0	.0	.0
1988	10	1.0	.0	300.0	15.0	.0	.0	.0	.0
1988	11	.0	.0	297.3	14.9	.0	.0	.0	.0
1988	12	.0	.0	294.5	14.8	.0	.0	.0	.0
1989	1	18.6	.0	300.0	14.9	.0	.0	.0	.0
1989	2	24.0	.0	300.0	15.0	.0	.0	.0	.0
1989	3	24.0	.0	300.0	15.0	.0	.0	.0	.0
1989	4	43.3	.0	300.0	15.0	.0	.0	.0	.0
1989	5	.0	.0	300.0	15.0	.0	.0	.0	.0
1989	6	38.2	.0	300.0	15.0	.0	.0	.0	.0
1989	7	.0	.0	300.0	15.0	.0	.0	.0	.0
1989	8	.0	.0	300.0	15.0	.0	.0	.0	.0
1989	9	14.3	.0	300.0	15.0	.0	.0	.0	.0
1989	10	1.0	.0	300.0	15.0	.0	.0	.0	.0
1989	11	.0	.0	297.3	14.9	.0	.0	.0	.0
1989	12	.0	.0	294.5	14.8	.0	.0	.0	.0

SIMULATION RESULTS FOR EXAMPLE 1 - TABLES DEVELOPED BY PROGRAM "TABLES"

MONTHLY SUMMARY TABLE FOR THE RIVER BASIN

NOTE: FOR NATURALIZED STREAMFLOW AND UNAPPROPRIATED FLOW, THE QUANTITIES SHOWN REPRESENT THE MAXIMUM FLOW AT ANY CONTROL POINT IN A GIVEN MONTH, BASED ON COMPARING ALL CONTROL POINTS. ALL OTHER QUANTITIES SHOWN ARE THE SUM OF THE VALUES FOR ALL THE CONTROL POINTS.

YEAR	MONTH	NATURALIZED STREAMFLOW (ACRE-FEET)	RETURN FLOW (AC-FT)	STREAMFLOW DEPLETION (ACRE-FEET)	UNAPPROPRIATED FLOW (ACRE-FEET)	EOP STORAGE (AC-FT)	EVAPORATION (ACRE-FEET)	PERMITTED DIVERSION (AC-FT)	ACTUAL DIVERSION (AC-FT)	SHORTAGE (AC-FT)
1988	1	150.0	79.0	219.5	59.5	699.5	35.0	185.0	185.0	.0
1988	2	150.0	79.0	219.5	59.5	699.0	35.0	185.0	185.0	.0
1988	3	150.0	79.0	219.5	59.5	698.6	34.9	185.0	185.0	.0
1988	4	180.0	79.0	171.0	98.0	650.9	33.7	185.0	185.0	.0
1988	5	180.0	79.0	269.0	.0	596.7	31.2	300.0	292.0	8.0
1988	6	180.0	129.5	279.5	40.0	547.5	28.6	300.0	300.0	.0
1988	7	50.0	132.0	192.0	.0	457.5	25.1	300.0	257.0	43.0
1988	8	50.0	108.0	168.0	.0	371.8	20.6	300.0	233.0	67.0
1988	9	50.0	78.6	118.8	19.8	321.7	17.3	185.0	151.3	33.7
1988	10	75.0	42.0	166.0	1.0	335.4	16.5	185.0	136.0	49.0
1988	11	75.0	34.4	159.4	.0	364.0	17.4	185.0	113.3	71.7
1988	12	75.0	34.0	159.0	.0	392.1	18.9	185.0	112.0	73.0
1989	1	150.0	65.0	246.4	28.6	446.5	20.9	185.0	171.0	14.0
1989	2	150.0	65.0	241.0	34.0	493.0	23.6	185.0	171.0	14.0
1989	3	150.0	65.0	241.0	34.0	537.2	25.8	185.0	171.0	14.0
1989	4	180.0	64.3	171.0	83.3	511.8	26.2	185.0	170.3	14.7
1989	5	180.0	76.5	266.5	.0	466.8	24.4	300.0	287.0	13.0
1989	6	180.0	127.7	279.5	38.2	426.7	22.4	300.0	297.3	2.7
1989	7	50.0	126.0	186.0	.0	371.7	20.0	300.0	221.0	79.0
1989	8	50.0	93.0	153.0	.0	343.4	17.8	300.0	163.5	136.5
1989	9	50.0	68.6	114.3	14.3	321.7	16.6	185.0	119.3	65.7
1989	10	75.0	42.0	166.0	1.0	335.4	16.5	185.0	136.0	49.0
1989	11	75.0	34.4	159.4	.0	364.0	17.4	185.0	113.3	71.7
1989	12	75.0	34.0	159.0	.0	392.1	18.9	185.0	112.0	73.0

SIMULATION RESULTS FOR EXAMPLE 1 - TABLES DEVELOPED BY PROGRAM "TABLES"

ANNUAL SUMMARY TABLE FOR THE RIVER BASIN

NOTE: FOR NATURALIZED STREAMFLOW AND UNAPPROPRIATED FLOW, THE QUANTITIES SHOWN REPRESENT THE MAXIMUM FLOW AT ANY CONTROL POINT IN A GIVEN MONTH, BASED ON COMPARING ALL CONTROL POINTS. ALL OTHER QUANTITIES SHOWN ARE THE SUM OF THE VALUES FOR ALL THE CONTROL POINTS.

YEAR	NATURALIZED STREAMFLOW (ACRE-FEET)	RETURN FLOW (AC-FT)	STREAMFLOW DEPLETION (ACRE-FEET)	UNAPPROPRIATED FLOW (ACRE-FEET)	EOP STORAGE (AC-FT)	EVAPORATION (ACRE-FEET)	PERMITTED DIVERSION (AC-FT)	ACTUAL DIVERSION (AC-FT)	SHORTAGE (AC-FT)
1988	1365.0	953.5	2341.2	337.3	392.1	314.2	2680.0	2334.6	345.4
1989	1365.0	861.5	2383.1	233.4	392.1	250.5	2680.0	2132.7	547.3

TAMUWRAP MODEL DESCRIPTION AND USERS MANUAL - APPENDIX C
SIMULATION RESULTS FOR EXAMPLE 1 - TABLES DEVELOPED BY PROGRAM "TABLES"

NATURALIZED STREAMFLOWS (AC-FT) AT CONTROL POINT CP1

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1988	60.	60.	60.	60.	60.	60.	10.	10.	10.	10.	10.	10.	420.
1989	60.	60.	60.	60.	60.	60.	10.	10.	10.	10.	10.	10.	420.

TAMUWRAP MODEL DESCRIPTION AND USERS MANUAL - APPENDIX C
SIMULATION RESULTS FOR EXAMPLE 1 - TABLES DEVELOPED BY PROGRAM "TABLES"

NATURALIZED STREAMFLOWS (AC-FT) AT CONTROL POINT CP2

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1988	20.	20.	20.	20.	20.	20.	0.	0.	0.	0.	0.	0.	120.
1989	20.	20.	20.	20.	20.	20.	0.	0.	0.	0.	0.	0.	120.

NATURALIZED STREAMFLOWS (AC-FT) AT CONTROL POINT CP3

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1988	120.	120.	120.	100.	100.	100.	30.	30.	30.	30.	30.	30.	840.
1989	120.	120.	120.	100.	100.	100.	30.	30.	30.	30.	30.	30.	840.

TAMUWRAP MODEL DESCRIPTION AND USERS MANUAL - APPENDIX C
SIMULATION RESULTS FOR EXAMPLE 1 - TABLES DEVELOPED BY PROGRAM "TABLES"

NATURALIZED STREAMFLOWS (AC-FT) AT CONTROL POINT CP4

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1988	120.	120.	120.	120.	120.	120.	40.	40.	40.	40.	40.	40.	960.
1989	120.	120.	120.	120.	120.	120.	40.	40.	40.	40.	40.	40.	960.

TAMUWRAP MODEL DESCRIPTION AND USERS MANUAL - APPENDIX C

SIMULATION RESULTS FOR EXAMPLE 1 - TABLES DEVELOPED BY PROGRAM "TABLES"

NATURALIZED STREAMFLOWS (AC-FT) AT CONTROL POINT CP5

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1988	60.	60.	60.	10.	10.	10.	10.	10.	10.	75.	75.	75.	465.
1989	60.	60.	60.	10.	10.	10.	10.	10.	10.	75.	75.	75.	465.

TAMUWRAP MODEL DESCRIPTION AND USERS MANUAL - APPENDIX C

SIMULATION RESULTS FOR EXAMPLE 1 - TABLES DEVELOPED BY PROGRAM "TABLES"

NATURALIZED STREAMFLOWS (AC-FT) AT CONTROL POINT CP6

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1988	150.	150.	150.	180.	180.	180.	50.	50.	50.	50.	50.	50.	1290.
1989	150.	150.	150.	180.	180.	180.	50.	50.	50.	50.	50.	50.	1290.

TAMUWRAP MODEL DESCRIPTION AND USERS MANUAL - APPENDIX C
SIMULATION RESULTS FOR EXAMPLE 1 - TABLES DEVELOPED BY PROGRAM "TABLES"

UNAPPROPRIATED FLOWS (AC-FT) AT CONTROL POINT CP1

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1988	15.	15.	15.	3.	0.	26.	0.	0.	0.	0.	0.	0.	72.
1989	0.	0.	0.	3.	0.	26.	0.	0.	0.	0.	0.	0.	29.

TAMUWRAP MODEL DESCRIPTION AND USERS MANUAL - APPENDIX C
SIMULATION RESULTS FOR EXAMPLE 1 - TABLES DEVELOPED BY PROGRAM "TABLES"

UNAPPROPRIATED FLOWS (AC-FT) AT CONTROL POINT CP2

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1988	0.	0.	0.	3.	0.	0.	0.	0.	0.	0.	0.	0.	3.
1989	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

TAMUWRAP MODEL DESCRIPTION AND USERS MANUAL - APPENDIX C
SIMULATION RESULTS FOR EXAMPLE 1 - TABLES DEVELOPED BY PROGRAM "TABLES"

UNAPPROPRIATED FLOWS (AC-FT) AT CONTROL POINT CP5

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1988	10.	10.	10.	0.	0.	0.	0.	0.	0.	0.	0.	0.	30.
1989	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

TAMUWRAP MODEL DESCRIPTION AND USERS MANUAL - APPENDIX C
SIMULATION RESULTS FOR EXAMPLE 1 - TABLES DEVELOPED BY PROGRAM "TABLES"

UNAPPROPRIATED FLOWS (AC-FT) AT CONTROL POINT CP6

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1988	60.	60.	60.	98.	0.	40.	0.	0.	20.	1.	0.	0.	337.
1989	29.	34.	34.	83.	0.	38.	0.	0.	14.	1.	0.	0.	233.

APPENDIX D

DEFINITION OF VARIABLES AND SUBROUTINES IN WRAP2

WRAP 2 Subroutines

The main program of WRAP2 contains a water rights computational loop embedded within monthly and annual loops. Most of the computations are performed by the subroutines, which are listed below. Subroutines LINEAR and CHECK are called by subroutines RESCAL and FILINI, respectively. The other subroutines are called by the main program.

FILINI - opens the input and output files.

CHECK - called by subroutine FILINI to check whether files exist.

WRAPIN - reads and organizes the input data, except for the streamflow (IN) and evaporation (EV)) records which are read by the main program.

AVALB - determines the amount of streamflow available at a control point for a water right.

INFADJ - reduces and increases the available streamflow at pertinent control points by the streamflow depletion and return flow, respectively.

RESCAL - performs the iterative reservoir evaporation computations.

LINEAR - performs linear interpolation.

FILE11(i,5) - return factor
FILE11(i,6) - output identifier - negative if a right to be output

AVAMT - available/unappropriated flow

CAPAC - water rights permitted storage capacity

DIV - amount by which an individual right depletes streamflow for diversion as well as storage

AMT - period permitted diversion amount = FILE11(i,1) times use factor

SHT - shortage for a water right

TDIV - amount by which to decrease downstream unappropriated flows = diversion minus return flow

EVCFA, EVCFB, EVCFC - storage area constants

Integer Variables

FILENUM(i,j)/(2000,3) - integer identifiers of location, use and reservoir associated with water right "i"
FILENUM(i,1) - locnum
FILENUM(i,2) - usenum
FILENUM(i,3) - resnum
FILENUM(i,4) - return flow locnum

CPNXT(i)/(50) - integer identifier of next downstream control point for control point "i"

RESTAB(i)/(2000) - integer identifier of storage area table for reservoir "i"

NWRTS - number of water rights - maximum 2,000

NRES - number of reservoirs - maximum 2,000

YRST - starting year of analysis

NYRS - number of years in analysis

NCPTS - number of control points

NPRDS - number of periods per year - maximum 12

NUSES - number of water use types - maximum 12

EVUNT - evaporation depths entered as inches/period (month)

NTABLE - number of storage-area tables - maximum 50

NWROUT - number of rights to output - maximum 100 or all

NREOUT - number of reservoirs to output - maximum 100 or all

LOCNUM - integer identifier of current control point

USENUM - integer use identifier

RESNUM - integer reservoir identifier

YEAR - current year

NPT - integer identifier of next downstream control point

Character Variables

FILEID(i,j)/(2000,4) - six-digit alpha numeric identifiers of entities associated with right "i"
FILEID(i,1) - water right ID
FILEID(i,2) - control point ID
FILEID(i,3) - use ID
FILEID(i,4) - reservoir ID
FILEID(i,5) - return location identifier

RESID(i)/(2000) - reservoir identifiers

TABLID(i)/(50) - identifiers of reservoirs with storage-area tables

CPID(i,j)/(50,2) - control point identifiers
CPID(i,1) - control point identifier
CPID(i,2) - downstream control point; 'OUT' if last control point

USEID(i)/(12) - use identifiers

TITLE1, TITLE2, TITLE3 - input data title information

Variables Exclusive to Main Program

Real Variables

CPRET(i)/(50) - summation of return flows returned to control point "i"

CPSUM(i,j,k)/(50,3,2) - summary period data for reservoirs at control point "i"
CPSUM(i,1,1) - total BPSTOR @ C.P. "i"
CPSUM(i,2,1) - total EPSTOR @ C.P. "i"
CPSUM(i,3,1) - total EVAP @ C.P. "i"
CPSUM(i,1-3,2)

PSUM(i)/(7) - period summary data for entire system
PSUM(1) - total inflow - temporary, intermediate values of the above 3
PSUM(2) - beginning-of-period storage

PSUM(3) - end-of-period storage
PSUM(4) - evaporation
PSUM(5) - summation of permitted diversion rights met - Σ (AMT-SHT)
PSUM(6) - total return flows
PSUM(7) - total unappropriated flow

YSUM(i)/(4) - yearly summary data for entire system
YSUM(1) - total inflow
YSUM(2) - total evaporation
YSUM(3) - total return flows
YSUM(4) - total unappropriated flow

DUMMY(i,j)/(50,12) - temporary array holding either evaporation data or inflow data as it is read in. Data is then sorted and placed in order corresponding to control point arrays.

INFLOW(i,j)/(50,12) - inflow at control point "i" during period "j"

TSTOR - summation of all reservoir storage capacities. It is computed but not used in program.

RETLST - summation of return flows lost to the system

RETURN - return flow from a water right

RFAC - return flow factor for a water right

WRFLAG - identifies reservoir right

TNUM - temporary value used in sort routine

<u>Integer Variables</u>

PYR - used when reading inflows and evaporation. If negative, the evaporation or inflow values are set equal to that of a previously entered control point. If positive, it is the year that inflows or evaporations occurred.

I,II,J,JJ,K,KK,ZZ,X,L - miscellaneous counters

<u>Character Variables</u>

CPIN(i)/(50) - holds control point identifiers as inflows are read in before they are sorted into correct order

CPEV(i)/(50) - same, but for evaporation identifier

REPEAT - identifier of control point that inflows and evaporations are to be repeated

CD - input data record

TCHARA - temporary identifier used in water rights sort routine

Subroutine AVALB (MH)

Subroutine AVALB determines the available streamflow at a control point.

Integer Variable

MH - current period

Subroutine RESCAL (MT,RIGHT)

Subroutine RESCAL performs iterative reservoir evaporation calculations.

Real Variables

ERRMAX - error criteria

EVCNST - evaporation depth

EPST1, EPST2 - first and second approximations of end-of-period storage

EVOL - evaporation volume

AVAIL - water available to refill reservoir

TOTAMT - amount to withdraw from reservoir

BPAREA - beginning period area

EPAREA - ending period area

AREAVE - (BPAREA + EPAREA)/2

DEPLET - streamflow depletion

ERR - ABS (EPST1 - EPST2)

Integer Variables

MAXIT - maximum number of iterations

I - iteration counter

RIGHT - integer number of current right

MT - current period

Subroutine INFADJ (MT)

Subroutine INFADJ reduces or increases the available streamflow at a control point and all downstream control points by the depletion and return amounts.

Integer Variables

MT - current period

WR - integer identifier of water right

Subroutine Linear (STORAG, AREA)

Subroutine LINEAR performs the linear interpolation of the storage-area tables.

Real Variables

STORAG - storage volume

AREA - area corresponding to storage area

X1, X2, Y1, Y2 - interpolation constants

Integer Variables

I - table location counter

TABNUM - integer identifier of storage-area table

MIN - table location of low point of interpolation

Subroutine FILINI

Subroutine FILINI reads the input file name root and opens and initializes the input and output files.

Integer Variable

P - counter to determine end of FILENAME ROOT

Character Variable

ROOT - 78-character string of root of filename

NAME - complete file name

Subroutine CHECK (NAME, P)

Subroutine CHECK is called by FILINI to check if a file currently exists.

Integer Variable

P - counter

Character Variable

NAME - file name

Logical Variable

TRY - true if file exists, false if it doesn't

Subroutine WRAPIN

Subroutine WRAPIN reads the input data, except for IN and EV records.

Real Variables

TOTAL - used to convert period use factors to decimal form

TARA(i)/(24) - temporary arrays to hold storage-area tables

TARB(i)/(24) - temporary arrays to hold storage-area tables

Integer Variables

MATCH - flag that counts the number of times a storage-area identifier matches reservoir identifiers

K,I,J, **X** - miscellaneous counters

Character Variables

CD - input record identifier

WROUT(i)/(100) - list of identifiers for rights and reservoirs to output

RESOUT(i)/(100) - list of identifiers for rights and reservoirs to output

Logical Variable

OLD - flag set if a reservoir has been entered by a previous water right

APPENDIX E

DEFINITION OF VARIABLES AND SUBROUTINES IN WRAP3

WRAP3 Subroutines

The main program of WRAP3 contains a water rights computational loop embedded within monthly and annual loops. Most of the computations are performed by subroutines called by the main program. The subroutines are listed below.

FILINI - called by main program to open input and output files.

CHECK - called by subroutine FILINI to check whether files exist.

WRAPIN - called by main program to read and organize the input data, except for the streamflow (IN) and evaporation (EV) records.

CONFLU - called by subroutine WRAPIN to determine the first downstream control point common to a water right and secondary reservoir and to specify whether the reservoir releases are limited to diversions at downstream locations.

RANKIT - called by main program to develop an array which identifies the water rights in priority order.

INFEVA - called by main program to read the streamflow (IN) and evaporation (EV) records and arrange them in the same order as the control points.

INCREM - called by main program to determine negative incremental flows and to adjust the streamflows in accordance with the option specified on the JD record.

AVALB - called by main program to determine the amount of streamflow available at a control point for a water right.

MINFLO - called by main program to determine the diversion requirement for a type 4 water right.

RELESE - called by main program to determine releases from secondary reservoirs.

INFADJ - called by main program to reduce and increase the available streamflow at pertinent control points by the streamflow depletion and return flow, respectively.

CUMREL - called by subroutine RELESE to accumulate releases from secondary reservoirs to downstream water rights.

RESCAL - called by main program and subroutines RELESE and POWER to perform iterative reservoir evaporation calculations.

LINEAR - called by main program and subroutines MINFLO, RESCAL, and POWER to perform linear interpolation.

POWER - called by main program to perform hydroelectric power calculations.

DEFINITION OF VARIABLES AND SUBROUTINES IN WRAP3

WRAP3 Variables

The variables in the main program and each subroutine are defined below. The common variables listed first are used in both the main program and subroutines. The limits on the size of a system which can be modeled with WRAP3 are set by the array dimensions cited below. Dimension limits can be changed by changing the values of these integer variables in the parameter statement.

Array Dimensions for Basic System Parameters

MAXWR = 2000 maximum number of water rights

MAXCP = 50 maximum number of control points

MAXRES = 2000 maximum number of reservoirs

MAXMON = 12 maximum number of periods (months) per year

MAXUSE = 12 maximum number of use types

MAXTAB = 50 maximum number of storage-area tables

MAXGP = 60 maximum number of water right groups for output

MAXRSO = 60 maximum number of reservoirs for output

MAXPOW = 50 maximum number of hydropower reservoirs

MAXSYS = 50 maximum number of reservoirs associated with a water right

MAXSTO = 50 maximum number of storage-flow rights

Common Variables

Real Variables

AMT - annual permitted diversion multiplied by monthly use factor for a right

AVAMT - available streamflow at a control point computed by subroutine AVALB

BPELEV - beginning period elevation

CPDT(MAXCP,2) - inflow (1) and evaporation (2) multiplication factors for each control point

CPFLOW(MAXCP,MAXMON,5) - miscellaneous flow values at a control point in each month
CPFLOW(,,1) - negative incremental
CPFLOW(,,2) - unappropriated flow

CPFLOW(,,3) - summation of streamflow depletion
CPFLOW(,,4) - summation of flows returned
CPFLOW(,,5) - summation of depletion minus summation of releases, used in making release decisions from secondary reservoirs

DIV - streamflow depletion made by a right

ELAVE - average elevation

EPELEV - end-of-period elevation

ERROR - iteration convergence in hydropower computations

EVAPR(MAXCP,MAXMON) - net evaporation rates at each control point each month of a year

EVCFA - first storage-area coefficient for a reservoir

EVCFB - second storage-area coefficient

EVCFC - third storage-area coefficient

EVCURV(MAXTAB,25) - storage-area tables for evaporation computations

FRMPOW - firm energy

INFLOW(MAXCP,MAXMON) - inflow at each control point each month of a year

INRES - inflow from a right into a reservoir

MAKEUP - amount desired to release from secondary reservoirs after depletion is made

OUTRES - outflow from a reservoir

PDUSCF(MAXUSE,MAXMON) - use factors for each use each month

POWFCT - conversion factor for hydroelectric energy computations. Converts flow per month and elevation into appropriate energy units in the equation

energy = POWFCT * Q * H * eff

POWPRO - energy produced

PVCURV(MAXPOW,25) - storage-elevation tables for hydropower computations

RELS - summation of releases from secondary reservoirs for a right

RESDAT(MAXRES,13) - reservoir data occurring in a month
RESDAT(,1) - maximum storage capacity of all type 1 and hydropower rights listed

RESDAT(,2) - EVCFA
RESDAT(,3) - EVCFB
RESDAT(,4) - EVCFC
RESDAT(,5) - beginning-of-period storage
RESDAT(,6) - end-of-period storage
RESDAT(,7) - evaporation
RESDAT(,8) - summation of depletions into a reservoir
RESDAT(,9) - releases through outlet works (turbines) from reservoir
RESDAT(,10) - "lakeside" releases from reservoir
RESDAT(,11) - releases from system reservoirs into
RESDAT(,12) - hydroelectric energy produced
RESDAT(,13) - highest firm power at reservoir

RETLST - return flow lost from system. Computed but not used.

RETURN - return flow

RFAC - return flow factor

SHT - diversion shortage for a right

STOFLO(MAXSTO,25) - storage-flow tables for type 4 rights

TWATER - tailwater elevation

WRDAT(MAXWR,4) - water right data
WRDAT(,1) - annual permitted diversion or annual firm energy
WRDAT(,2) - return flow factor
WRDAT(,3) - bottom of inactive pool if only reservoir associated with right
WRDAT(,4) - top of inactive pool if only reservoir associated with right

WRSYS(MAXSYS,6) - data describing reservoir system for a water right with multiple reservoirs. This data is saved on UNIT10 and UNIT11 scratch files to conserve core memory.
WRSYS(,1) - storage at top of inactive zone or constant tailwater elevation if hydropower for each reservoir
WRSYS(,2) - storage capacity at top of zone 2 if secondary reservoir, bottom of power pool if hydropower
WRSYS(,3) - top of zone 1, storage capacity or top of power pool
WRSYS(,4) - zone 2 release factor or water-to-wire efficiency
WRSYS(,5) - zone 1 release factor
WRSYS(,6) - release made by reservoir to meet permitted diversion

<u>Integer Variables</u>

ADJINC - defines negative incremental inflow option to be used

ADJOUT - defines whether to write negative inflow adjustments file

CPNXT(MAXCP) - contains the indices of the next downstream control point for each control point

GPNUM - index of group identifier for each water right

GPOUT - flag to output either water right identifiers or group identifiers

LOCNUM - index of control point

MT - current month of simulation

NCPTS - number of control points in a basin

NGOUT - number of groups listed for output on JG record

NPRDS - number of months in a year

NPT - index of next downstream control point

NPTABL - number of storage-elevation tables

NREOUT - number of reservoirs for output

NRES - number of reservoirs in a basin

NUMPOW - number of hydropower rights in basin

NUSES - number of use types

NWROUT - number of water rights flagged for output by groups on JG record

NWRTS - number of water rights in a basin

NYRS - number of years in a simulation

OUTPT - flag to output right, same as WRNUM(,6)

RANK(MAXWR) - contains the indices of water rights in order of priority

RESNUM(MAXRES,4) - various indices pertaining to a reservoir
RESNUM(,1) - control point location index
RESNUM(,2) - index of storage-area table
RESNUM(,3) - flag to output reservoir
RESNUM(,4) - index of storage-elevation table

RETNUM - index of control point for return flows

STFL - index of storage-flow table for a type 4 right

STOFLG - flag to use either beginning-of-period or end-of-period storage when making reservoir release decisions

SYSNUM(MAXSYS+1,2) - indices of reservoirs associated with a water right.
SYSNUM(,1) - reservoir indices
SYSNUM(,2) - index of first control point located downstream of water right location and reservoir location
SYSNUM(,3) - negative if a lakeside release

SYSOUT - flag to output data to system file

TYPE - water right type

USENUM - index of use type

WR - integer identifier of water right

WRNUM(MAXWR,10) - various water right flags and indices
WRNUM(,1) - control point index
WRNUM(,2) - use type index
WRNUM(,3) - return control point index
WRNUM(,4) - group identifier index
WRNUM(,5) - type
WRNUM(,6) - flag to output right
WRNUM(,7) - priority number (date)
WRNUM(,8) - STFL
WRNUM(,9) - index of primary reservoir or index of system data record in scratch file
WRNUM(,10) - same as SYSNUM(,2) if only one reservoir listed
WRNUM(,11) - same as SYSNUM(,3) if only one reservoir listed

YEAR - current year in simulation

YRST - first year in simulation

Character Variables:

CPID(MAXCP,2)*6 - control point and next downstream control point identifiers

GROUP(MAXGP)*6 - group identifiers listed on JG records

REOUID(MAXRSO)*6 - reservoir identifiers listed on JR records

RESID(MAXRES)*6 - reservoir identifiers

USEID(MAXUSE)*6 - use type identifiers

WRID(MAXWR)*6 - water right identifiers

TITLE1*78 - first title (on T1 record)

TITLE2*78 - second title (on T2 record)

TITLE3*78 - third title (on T3 record)

RCP*6 - return control point identifier

CD*2 - record identifier

Variables Exclusive to Main Program

Real Variables

BPAREA - beginning-of-period area

BPSTOR - beginning-of-period storage

CPRET(MAXCP) - summation of return flows returned to each control point

CPSUM(MAXCP,4) - monthly control point summary data
CPSUM(,1) - diversion shortages
CPSUM(,2) - permitted diversions
CPSUM(,3) - reservoir evaporation volumes
CPSUM(,4) - end-of-period storages

EPAREA - end-of-period area

EPSTOR - end-of-period storage

EVOL - evaporation volume

Integer Variables

P - index used in character data manipulation

RECORD - index of current record of direct access output file

Character Variable

NAME*80 - file name

ROOT*76 - root of file name

TITLE0*80 - first line of each output file

Subroutine FILINI (ROOT)

Subroutine FILINI reads the input file name root and opens and initializes the input and output files.

Integer Variable

P - index used in character data manipulation

<u>Character</u>

ROOT*76 - root of file name

NAME*80 - file name

SCPATH*40 - path for scratch files

Subroutine CHECK (NAME,P)

Subroutine CHECK is called by FILINI to check if a file currently exists.

<u>Integer Variable</u>

P - index used in character data manipulation

<u>Character Variables</u>

NAME*80 - file name

CHR - interactive user input to control program execution

<u>Logical Variable</u>

TRY - flag to determine if flag exists

Subroutine WRAPIN

Subroutine WRAPIN is used to read the basin input data.

<u>Real Variables</u>

TARA(24),TARB(24) - temporary arrays storing reservoir storage-flow, storage-area, and storage-elevation data

TOTAL - used to sum the monthly use distribution factors to convert to decimal fractions

<u>Integer Variables</u>

I,J,K,X,Z,ZZ - miscellaneous counters

MATCH - flag to determine duplicate or missing storage-area and storage-elevation tables

STSYS - counter to determine the number of lines written to scratch files saving reservoir system and hydropower data

PTBCNT - counter of storage-elevation tables read

STBCNT - counter of storage-flow tables read

TEMP - temporary integer variable

Character Variables

RES*6,CP*6,USE*6,GP*6 - temporary variables holding reservoir, control point, use, and group identifiers

Logical Variable

INISTO - flag determining initial storage at reservoir

OLD - used as flag to determine if a reservoir has been entered with a previous right

Subroutine CONFLU(K)

Subroutine CONFLU determines the first common control point common to both a secondary reservoir and a water right and determines from input data how releases are to be limited.

Integer Variables

I - counter

K - water right index

WRPT - water right location index

RESPT - reservoir location index

Subroutine RANKIT

Subroutine RANKIT determines the priority order indices of the water rights.

Integer Variables

I,II - counters

K - temporary index

Subroutine INFEVA

Subroutine INFEVA reads the inflow and evaporation data.

Real Variable

DUMMY(MAXCP,MAXMON) - temporary array of values

__Integer Variables__

J,K,L,M,X - counters

PYR - year being read

__Character Variables__

CPIN(MAXCP)*6 - control point identifiers

REPEAT*6 - identifier of control point from which to repeat data

Subroutine INCREM

Subroutine INCREM calculates and adjusts negative incremental inflows as specified on JD record.

__Real Variables__

TEMP(MAXCP,2) - temporary array holding intermediate values of the incremental inflows

__Integer Variables__

I,J,Z - miscellaneous counters

MAXIT - maximum number of passes through the control point system accumulating negative incrementals. MAXIT=NCPTS+1

__Logical Variables__

CHANGE - checks current pass through control point system to check if an accumulated negative incremental has changed from previous pass

Subroutine AVALB (LOC,AVAIL)

Subroutine AVALB determines the available streamflow at a control point.

__Real Variable__

AVAIL - available water to a point

__Integer Variable__

LOC - control point location index

Subroutine MINFLO

Subroutine MINFLO determines the diversion requirements for a type 4 water right.

Real Variables

AMT1 - diversion requirement interpolated from storage-flow table

TSTOR - total storage in reservoirs associated with the right

Subroutine RELESE

Subroutine RELESE calculates releases from secondary reservoirs.

Real Variables

PASSNC - amount of streamflow that a right passed above the first common downstream control point

TEMREL - release amount from a secondary reservoir

TEMPR - temporary real number

EPSTOR - end-of-period storage

EVOL - evaporation volume

PRTY(MAXSYS) - priority numbers of reservoirs

Integer Variables

ZONE - counts the number of reservoirs eligible to release from a storage zone

I,J - miscellaneous counters

HILO - flag to determine which storage zone to check

FIRST - first secondary reservoir in system list

CHCKST - flag enabling release decisions to be made with either end-of-period or beginning-of-period storage

SYSRES,RESINT - reservoir indices

PT - control point index

TEMPI - temporary integer variable

CONFL - index of first downstream control point common to both water right and secondary reservoir

PRIREL(MAXSYS) - indices of secondary reservoirs in priority order

Subroutine INFADJ

Subroutine INFADJ reduces or increases the available streamflow at a control point and all downstream control points by the depletion and return amounts.

Integer Variables

MONTH - month in which to place return flows

Subroutine CUMREL (LOC,REL)

Subroutine CUMREL accumulates releases from secondary reservoirs to downstream water rights.

Real Variable

REL - reservoir release

Integer Variables

LOC,PT - control point indices

Subroutine RESCAL (IDNUM,LOSTOR,HISTOR,IN,OUT,EPSTOR,EVOL)

Subroutine RESCAL performs iterative reservoir evaporation calculations.

Real Variables

LOSTOR,HISTOR - bottom and top of inactive pool

IN,OUT - water made available to and required from by the current right

ERRMAX - maximum allowable difference between subsequent end-of-period storages. Convergence criteria

EVACST - evaporation depth

OUTEST - estimate of reservoir outflow to meet diversion and release requirements

EPST1,EPST2 - subsequent estimates of end-of-period storage

AREAVE - average reservoir surface area

ERR - difference between subsequent end-of-period storage estimates

PREOUT,PREIN - water previously released and made available by senior rights

INEST - estimate of water made available to reservoir

BPSTOR,EPSTOR - beginning and end-of-period storages

BPAREA,EPAREA - beginning and end-of-period surface areas

EVOL - evapaoration depth

Subroutine LINEAR(GIVEN,FIND,NUM,DUMMY)

Integer Variables

IDNUM - reservoir identifier index

MAXIT - maximum number of iteration

I - counter

Subroutine LINEAR performs all linear interpolations.

Real Variables

GIVEN - value entering the table

FIND - interpolated value

DUMMY(MAXTAB,25) - interpolation table

X1,X2,Y1,Y2 - table values used for interpolation

Integer Variables

I - counter

NUM - table identifier index

MIN - table value index

Subroutine POWER

Subroutine POWER performs all calculations for hydropower rights.

Real Variables

ERRMAX - maximum allowable error. Convergence criteria

ERR - difference between subsequent approximations

EPST1,EPST2 - subsequent estimates of end-of-period storage

HISTOR - top of active pool

INPOW - water into reservoir

OUTPOW - water released from reservoir

TARGET - target streamflow depletion

IN - same as INPOW

BPSTOR,EPSTOR - beginning and end-of-period storages

BPAREA,EPAREA - beginning and end-of-period reservoir surface areas

EVOL - evaporation volume

DIVSTO - streamflow depletion to replenish storage

RELSTO - secondary reservoir releases to replenish storage

Integer Variables

I - counter

MAXIT - maximum number of iterations.

IDNUM - primary reservoir identifier index

APPENDIX F

DEFINITION OF VARIABLES AND SUBROUTINES IN TABLES

TABLES Subroutines

The main program of TABLES checks the identifier in the first field of each record of the input file, opens the required files, and calls the subroutines. The subroutines read the WRAP input and/or output files and develop the specified tables and data listings. The subroutines are listed below.

TITLES - writes the title records on the cover page and at the top of each table.

CVPAGE - writes the cover page for the output tables.

SUMDAT - from a WRAP2 or WRAP3 input file: writes a listing of selected records; develops a water rights summary; and sorts water rights in priority order by control point, use, type, or group.

RANKIT - determines priority order of water rights read from WRAP input file by subroutine SUMDAT.

SUMTAB - develops summary tables of monthly and/or annual WRAP2 or WRAP3 output data for a control point, water right, reservoir, of the entire river basin (sum of control points).

TABLE - develops a table of monthly and annual data for a control point, water right, or reservoir. The data consists of either naturalized flows, unappropriated flows, streamflow depletions, shortages, or reservoir storage.

RELIAB - develops a summary table of reliabilities and number of shortages for specified control points, water rights, or hydroelectric power reservoirs.

PERSTO - develops tables of monthly end-of-period storages expressed as a percentage of capacity. Also develops reliability table for reservoir drawdowns similar to tables developed by RELIAB.

HECIN - develops IN and EV records in either HEC-3 or HEC-5 format from naturalized flows, unappropriated flows, and/or streamflow depletions read from a WRAP output file and evaporation rates from a WRAP input file.

YFRLOW - called by subroutine HECIN to develop IN records.

SYSTAB - develops monthly and annual tables of reservoir releases for water rights and water rights groups.

TABLES Variables

Character Variables

CD - record identifier found in first four characters of each record of a TABLES input file.

CDEV - record identifiers in WRAP input file read by subroutine HECIN.

CDHEC - record identifier (IN or EV) on records output by subroutine HECIN.

CHAR- miscellaneous character variable.

CP, USE, RES, GP - temporary identifier variables.

CPID(50) - control point identifier.

GROUP(60), USID(12), CPID(50), RESDID(2000), WRID(2000) - group identifiers listed for output, use identifiers, control point identifiers, reservoir identifiers, and water right identifiers in a WRAP input file.

IDEN(ID,30) - identifiers for control points (ID=0), water rights (ID=1), or reservoirs (ID=2), or water right groups (ID=3).

IDEN(50,6) - identifiers for water rights associated with control points in subroutine HECIN.

INPUT - TABLES input file name.

JOBT - record identifier, same as CD, used in subroutine SUMDAT.

OUTPUT - TABLES output file name.

REC(15) - two-character identifiers of WRAP input data records to be listed, or not listed, by subroutine SELREC.

SYSRES(15) - identifiers of reservoirs listed for a water right in system file.

TITLE(5) - title records from a TABLES input file.

TITLE1, TITLE2, TITLE3 - title records from a WRAP input file.

TMPRES(15) - temporary array of reservoir identifiers.

WRAP - first portion of the first line of a WRAP output file which is reproduced on the TABLES cover page.

WRAPID - control point, water right, or reservoir identifier found in the WRAP output file.

WRAPIN - WRAP input file name.

WRAPOU - **WRAP** output file name.

Integer Variables

AVPERC - average percentage of active storage for all reservoirs listed by a 2PER record.

CAP(12,2) - top and bottom of active storage of reservoirs listed by a 2PER record.

COUNT - the number of either control points, water rights, or reservoirs for which to develop tables or to include in the tables.

COUNT1(50) - control point counter.

COUNT2(6) - water right counter for the current control point.

CREC - record counter used to go to the next block of monthly data in reading the direct access WRAP output file. CREC = NWROUT + NCPTS + NREOUT

EV - inputted parameter of whether EV records are output by HECIN.

EVCPTS - number of control points which have evaporation records.

EVCT(50) - evaporation control point counter.

EVID(50) - reservoir identifier on HEC EV record.

HEC - inputted parameter of whether IN and EV records output by HECIN are in HEC-3 or HEC-5 format.

I - miscellaneous counter.

ID -indicated either a control point (ID=0), water right (ID=1), or reservoir (ID=2).

INCP(50) - control point identifier on HEC IN record.

J - miscellaneous counter.

JTYPE1, JTYPE2, JTYPE3 - number of TABLES input records which specify job type 1, 2, and 3 output, respectively.

JTOTAL - total number of records in TABLES input file.

K - miscellaneous counter.

KK - miscellaneous integer variable.

LOOP - counter for the computational loops repeated for each of the COUNT control points (ID=0), water rights (ID=1), or reservoirs (ID=2) as identified by IDEN (ID,LOOP).

MATCH - flag to determine if groups for input match groups for output.

MC(12,8) - the number of months (periods) for which the shortage equals or exceeds specified percentages of the target diversion amount.

MNAN - input parameter which specifies whether monthly or annual summary tables are to be developed.

MONTH - current month (1,2,3,...,12).

NUM - parameter used in several input records to specify the number of values of a variable to follow in the remaining fields of the input record.

N - number of periods (months) in the simulation. N = NYRS * NPRDS

NCPTS - number of control points included in the WRAP output file.

NEGYR - flag used in subroutine HECIN to not write "negative year" message.

NGOUT - number of groups listed in a WRAP input file for output.

NPRDS - number of periods per year. NPRDS = 12 for a monthly time interval.

NREOUT - number of reservoirs included in the WRAP output file.

NRES - number of reservoirs included in a WRAP input file.

NRIGHT - number of rights included in a WRAP input file.

NTITLE - number of title records included in the TABLES input file.

NUSES - number of uses listed in a WRAP input file.

NUMCP - number of control points in a WRAP input file.

NWROUT - number of water rights included in the WRAP output file.

NYRS - number of years in the simulation.

PERC(12) - end-of-period storage as percentage of active storage capacity for reservoirs listed by a 2PER record.

PERIOD - current month.

PRHI,PRLO - highest and lowest priority numbers listed for a control point, type, use type, or water right group.

TABLES Variables (Continued)

QREAD - flag to determine if the input data has been read in with a previous type 1 record.

RANK(2000) - listing of water right indices in priority order.

REC1 - record counter used to locate the first control point, water right, or reservoir/hydropower record to be read from the direct access WRAP output file.

RECORD - record counter for reading WRAP output file (unit-4).

RESDAT(2000) - storage capacities of all reservoirs listed in a WRAP input file.

RESFLAG - flag used to count reservoirs associated with a right.

RESNUM(2000) - reservoir location control point indices.

SCRNUM - flag variable to determine type of table to be built.

SKIP,LOOP,COUNT - counter variables used to move between records in a WRAP output file.

STO(12) - end-of-period storages for reservoirs listed by a 2PER record.

STOAVE(12) - average end-of-period storage for reservoirs listed by a 2PER record.

STOR - miscellaneous variable summing storages in WRAP input file.

SUMDIV,SUMSTO - summation of storage and annual diversion amounts listed for a control point, type, use type, or water right group in a WRAP input file.

SUMWRT,SUMRES - a total number of water rights and reservoirs listed for a control point, type, use type, or group as grouped on a 2SRT record.

TAMT,TSHT - temporary variables summing diversion amounts and shortages.

TOTDIV,TOTSTO - miscellaneous variables summing storages and annual diversion amounts in a WRAP input file.

TPRHI,TPRLO - highest and lowest priority numbers listed in a basin.

WRDAT(2000) - array of water right storage capacities and annual diversion amounts.

WRNUM(2000,6) - array of index numbers for reservoirs, control points, use type, etc. for each right listed in a WRAP input file.

YC(7) - the number of years for which the shortage equals or exceeds specified percentages of the target diversion amount.

YEAR - current year.

YRST - first year in the simulation.

YRLAST - last year in the simulation

Real (Floating-Point) Variables

AMT - target diversion amount.

DATA(12) - monthly streamflow data.

EVAP(30,100,12) - monthly reservoir evaporation rates from EV records.

EVFAC - factor by which streamflow data is multiplied.

INFAC - factor by which evaporation rates are multiplied.

FLOW - streamflow data.

PERREL - period reliability.

MDATA(12) - monthly data printed by subroutine TABLES for each period (12 months of the year) for the current year. The data may be either naturalized flows (2NAT), unappropriated flows (2UNA), streamflow depletions (2DEP), shortages (2SHT), or storage (2STO).

- monthly data printed by subroutine SUMTAB in a summary table for a control point, water right, or reservoir (as specified by a 2SCP, 2SWR, 2SRE, or 2SGP input record, respectively) as follows:

	2SCP	2SWRRR	2SRE
naturalized streamflow	MDATA(8)	-	-
return flow	MDATA(7)	-	-
unappropriated flow	MDATA(6)	-	-
available streamflow	-	MDATA(6)	-
streamflow depletion	MDATA(5)	MDATA(5)	MDATA(5)
storage	MDATA(4)	MDATA(4)	MDATA(4)
storage change	-	MDATA(10)	MDATA(10)
evaporation	MDATA(3)	MDATA(3)	MDATA(3)
permitted diversion	MDATA(2)	MDATA(2)	-
actual diversion	MDATA(9)	MDATA(9)	-
shortage	MDATA(1)	MDATA(1)	-
releases from system	-	MDATA(7)	-
power produced	-	-	MDATA(2)
power shortage	-	-	MDATA(1)
depletions into reservoir	-	-	MDATA(5)
releases into reservoir	-	-	MDATA(6)
depl's and rel's into reservoir	-	-	MDATA(9)
releases through outlet works	-	-	MDATA(7)
releases from reservoir pool	-	-	MDATA(8)
total releases from reservoir	-	-	MDATA(11)

RELMON(15) - monthly releases for a water right or water right group.

RELYR(15) - annual releases for a water right or water right group.

SAMT(7) - a specified percentage of the target diversion amount for the current month.

TMPREL(15) - temporary array of reservoir releases.

SYAMT(7) - a specified percentage of the annual target diversion amount.

SDATA(10)- sum of the monthly data, MDATA, for all the control points.

TOTAMT - total volume of the target diversion amount over the entire simulation period.

TOTSHT - total volume of the shortages over the entire simulation period.

VOLREL - volume reliability.

YDATA(10) - yearly total of the control point sums, SDATA.

YTOTAL - yearly total of monthly data, MDATA.